FOLSOM

THE LINDENMEIER SITE

FRANK H.H. ROBERTS, JR.

— AND —

GEOLOGIC ANTIQUITY OF THE LINDENMEIER SITE IN COLORADO

KIRK BRYAN AND LOUIS L. RAY

COLLECTED PAPERS OF THE SMITHSONIAN INSTITUTION 1934-1940

FOLSOM

THE LINDENMEIER SITE

FRANK H.H. ROBERTS, JR.

— AND —

GEOLOGIC ANTIQUITY OF THE LINDENMEIER SITE IN COLORADO

KIRK BRYAN AND LOUIS L. RAY

COLLECTED PAPERS OF THE SMITHSONIAN INSTITUTION 1934-1940

About The 2007 Reprint Edition

Although Edwin M. Wilmsen utilized Frank H.H. Roberts' collections and notes to produce a comprehensive report on this all-important Folsom site, there is much in these original reports of the excavator which is not included in that work. These original reports have the flavor of the scholar who actually worked at the site and was making his observations in the early days of Paleo-Indian research.

While the original papers are sometimes available in libraries and a full set could be acquired from the marketplace, if one were patient and prepared to expend the required funds, there is much to be said from the standpoint of time, money and personal satisfaction for having a comprehensive copy at one's fingertips.

It is for the archaeological scholars who feel that the review of all relevant literature is essential to credible research and for the amateurs who are fascinated by, and want to have a better understanding of, these long-gone hunters that the original papers have been compiled into this reprint edition.

Republished September, 2007 by Gustav's Library, Davenport, IA in association with Ancient Society Books, Macomb, IL.

Facsimile Reprint, 2007

GUSTAVS LIBRARY

www.gustavslibrary.com
1011 E High St., Davenport, Ia 52803
(877) 520-9872

ANCIENT SOCIETY BOOKS
3100 W. ADAMS RD. MACOMB, IL 61455
(309) 836-3811

Table of Contents

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1934

(PUBLICATION 3300)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1935

A FOLSOM CAMP SITE AND WORKSHOP

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

A significant addition to the material illustrating an early phase of aboriginal American culture was obtained during October and November, 1934, in northern Colorado, where traces of a camp site and workshop attributable to so-called Folsom Man were brought to light. A whole series of implements—several types of scrapers, a variety of cutting edges, drills, engraving tools, and numerous examples of the characteristic Folsom point—were found in situ in a dark layer of earth 14 feet below the present ground level (figs. 54, 55). This layer, exposed in the side of a deep, narrow gully, also contained quantities of cut and broken animal bones, stone chips and flakes resulting from the manufacture of tools, charcoal and ashes, and other refuse such as accumulates around a habitation (fig. 56.) The concentration undoubtedly was a midden, and traces of habitations probably are nearby, although none was found. Prior to this find, the only traces of a presumably early hunting people were typical finely chipped points of stone, but now there is a definite complex of associated implements. In addition, the stone flakes give evidence of the technique employed in the manufacture of implements, and the spalls and nodules indicate that the stone-working was done on the spot. Considerable raw material is available near the site, and this may have been one of the attractions which led to its occupation.

The discovery was due to information furnished by Maj. Roy G. Coffin, of Colorado State College, Fort Collins, through Dr. John B. Reeside, of the United States Geological Survey. Correspondence between the writer and Major Coffin indicated that an inspection of the locality was warranted and the owner of the land, William Lindenmeier, Jr., of Fort Collins, gave permission for the investigations. The site was originally located by Judge C. C. Coffin and his son, A. L. Coffin, about 10 years ago, and since then they and Major Coffin have collected numerous specimens from the surface. They were impressed with the fact that all of the points differed from the usual Indian arrowheads found in the region but were not aware of their significance until 5 years ago, when Dr. E. B. Renaud, of the University of Denver, explained that they were Folsom points. Dr. Renaud was examining local collections with the view of plotting

Fig. 54.—General view of the district. Site is in gully bank to right of car in middle foreground.

Fig. 55.—Location of midden deposit. Man is standing on level where material was found. Picture taken at beginning of investigations.

FIG. 56.—Layer containing bones and implements. Objects came from bottom of dark earth. Large bone fragments in situ.

FIG. 57.—Series of implements. Third from left in top row is a typical Folsom point.

distribution maps for various types of implements, when he noted the points in the Coffin series. He visited the site where they were found and mentioned it in his report. No actual work was done there, however.

When the writer was taken to the place where the points were found, he observed that it was a denuded area and that the specimens recovered had undoubtedly been in top-layer material which had been eroded away by wind and water. The stone implements, being heavy, had remained until picked up. This location promised little from the standpoint of digging. On the second day, while exploring the adjacent terrain in company with the writer, Judge Coffin picked up a portion of a Folsom point along the bank of the ravine a quarter of a mile from the spot where the Coffin specimens were found. Close inspection of the precipitous bank revealed an undisturbed and intact layer of midden material. Work was started, with the results summarized in the first paragraph.

The type of point designated Folsom is not a new discovery, nor was it restricted to a small geographical area. Variations of the form have been found from the Rockies to the Atlantic, from southern Canada to the Gulf of Mexico. It is represented in collections in numerous museums and in at least one instance has been called by another name. It did not attract particular attention, despite its individual characteristics, because the examples were all surface finds. Its true significance was established in 1927, however, by the Colorado Museum of Natural History at Denver, and the interest focused upon it has brought to light many specimens which had previously passed unnoticed. The points which became the pattern for the type were found near the small town of Folsom, N. Mex.—hence the name. They were in association with skeletons of an extinct species of bison, one which is considered as having lived at the close of the glacial period. Since then other points of that type have been found at different localities along with bones of the musk ox and mammoth, which are also ice-age animals. The supposition that the type represents considerable antiquity rests upon these associations. Whether the finds actually date man in North America at the beginning of the post-glacial period or demonstrate a later survival of ice-age animals is a phase of the problem which the geologist and the paleontologist must solve. Archeologists generally concede that the points belong to the earliest phase of aboriginal American culture yet discovered. The main importance of the Colorado finds lies in the fact that for the first time a variety of implements is known for that horizon.

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1935

(Publication 3382)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1936

FURTHER INVESTIGATIONS AT A FOLSOM CAMPSITE IN NORTHERN COLORADO

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

The Lindenmeier Site in northern Colorado, where the presence of a campsite and workshop attributable to Folsom Man was established a year ago last autumn,[1] was the scene of additional excavations during the summer of 1935. From the first of June until early September the writer, assisted by a group of from 7 to 12 students, conducted a series of investigations in the deposits where stone implements and other traces of human occupation occur. The site is on an old valley bottom, which, owing to the eroding away of the ridges that once bordered it along one side, now constitutes a terrace above an intermittent tributary to a series of streams which ultimately join the South Platte River. The work in 1934 was confined to a deep deposit of midden material exposed in the side of a ravine that cuts across the terrace in the once occupied area. The plan of procedure in 1935 called for the digging of two large trenches through the section lying between the edge of the terrace and the ravine (fig. 74). The trenches were started several hundred feet apart but were directed so that they would converge at the pit where most of the previous finds had been made (fig. 75). This method of digging was adopted for the purpose of exposing a complete cross-section of the fill overlying the old valley bottom and of determining, if possible, where the artifacts found in the deep deposit had originated.

Only one trench was carried through to completion. The other was stopped when it became apparent that the evidence from it would merely duplicate that from the first one. The completed trench was 280 feet long and 10 feet wide, and sloped from a depth of 3 feet at the edge of the terrace to 17 feet in the bank of the ravine (fig. 76). The bottom followed the old soil level, which was the surface of the ground at the time when the site was inhabited by the makers of the tools found there (fig. 77). The trenches were dug in 10-foot sections, and all of the material from each was so designated. In addition the position of specimens with respect to location in the section

[1] Roberts, F. H. H., Jr., A Folsom Complex, preliminary report on investigations at the Lindenmeier Site in Northern Colorado. Smithsonian Misc. Coll., vol. 94, no. 4, 1935.

FIG. 74.—General view of site showing ravine and trenches across terrace.

FIG. 75.—Removing overburden at end of one trench. Platform on which dirt is piled is level of the deep deposit.

FIG. 76.—Sifting dirt from lower levels to insure recovery of all artifacts.

FIG. 77.—Specimens in position before removal. The object at the left is a chopper, that at the right a portion of a Folsom point.

was carefully noted. Detailed drawings were made of the faces in each section, and these give a minute record of events involved in the growth of the valley fill.

Much additional information concerning the cultural complex of the early hunting people who fashioned the characteristically fluted Folsom points (fig. 78) was obtained from the trenches. The digging also yielded some 750 stone implements and a few ornaments, one of carved bone, as well as bones from animals whose flesh had contributed to the food supply of the one-time dwellers at the site. No human skeletal material was found, and although bits of charcoal and ashes were encountered, no indications of a shelter or habitation were observed. The presence of hammerstones and numerous flakes and chips at several different places indicated that one or several individuals had been seated there while shaping tools out of rough stone nodules. Pieces of a number of projectile points which had been broken in the making were recovered from one such spot. By fitting the fragments together and restoring the flake to its original form it is possible to gain additional evidence on the technique used in the manufacture of the points.

One significant find bears directly upon the problem of the association between the implements and the bones occurring at the site, a feature which has been questioned. A considerable portion of the skeleton of one bison was uncovered with the bones still articulated. When the vertebrae were being removed, the tip end of a projectile point was discovered *in situ* in the foramen, the channel for the spinal cord, of one vertebra. As this bone had been in position in the center of a group of articulated vertebrae there was no possibility of the point being a later intrusion and postdating the skeleton (fig. 79). This association establishes beyond the shadow of a doubt the contemporaneity of the implements and the bones. The bison is one of the extinct species, *Bison taylori*. The point, hafted on either an arrow or spear shaft, was obviously driven into the animal and then broken off. The wound may not have been directly responsible for the creature's death, but it would have crippled it to such an extent that a killing blow could easily be administered.

Nine species of invertebrates were found in association with the animal bones and implements. Seven live in the region today, but two of the species are considerably north of their present range and may possibly indicate a warmer climate at the time of the deposition of the fossils. The present northern limits of one is Grand Canyon, Ariz., and southern and central New Mexico. The other occurs only

FIG. 78.—Typical Folsom points.

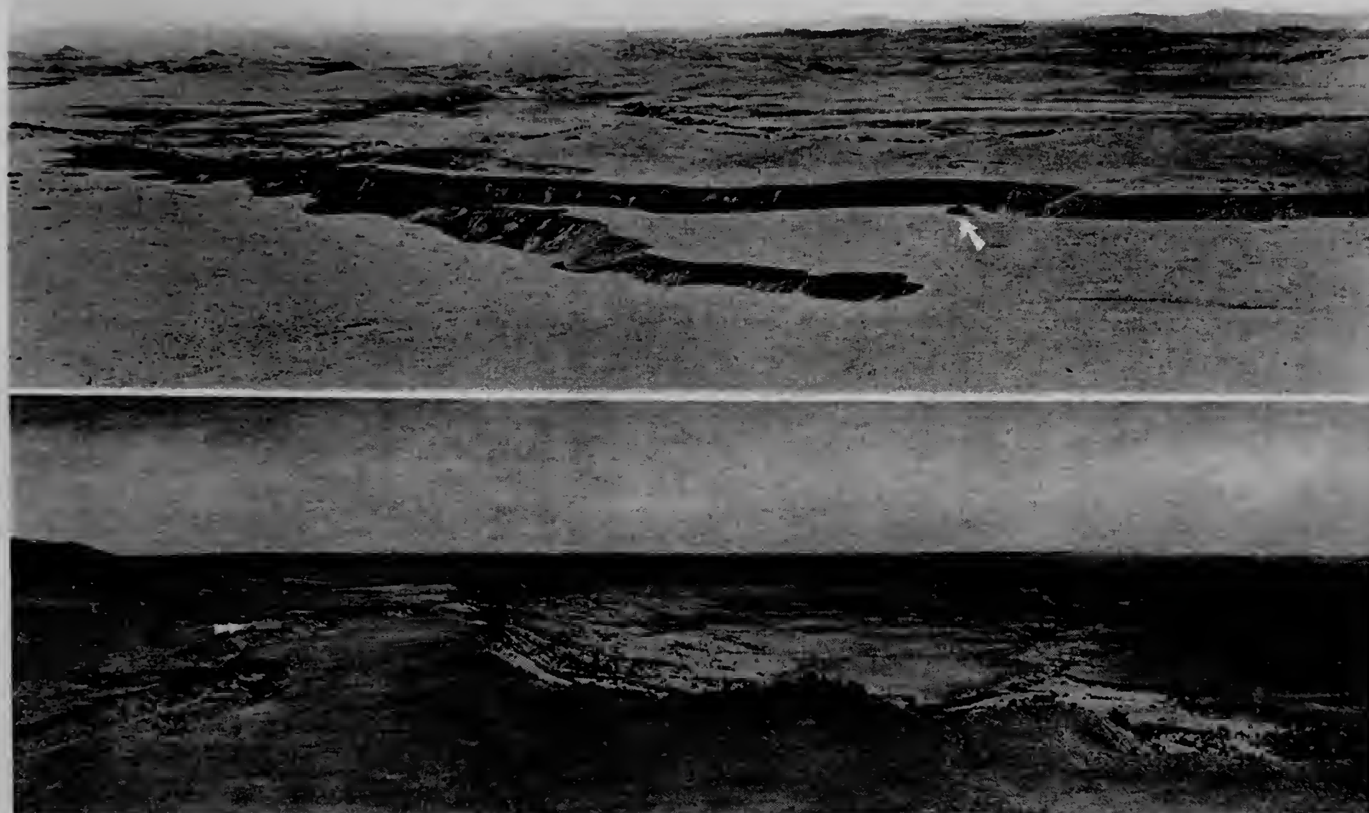
as far north as Mora County, New Mexico. The invertebrates were studied by Dr. Horace G. Richards, research associate, New Jersey State Museum, and his identifications and conclusions were verified by Dr. H. A. Pilsbry, Academy of Natural Sciences, Philadelphia.

Dr. Kirk Bryan, Division of Geology, Harvard University, assisted by F. T. McCann and John T. Hack, spent the month of July studying the geology of the district in an effort to determine the age of the deposits. Numerous geologists and paleontologists visited the site

Fig. 79.—Tip end of projectile point in place in vertebral foramen.

during the time that Dr. Bryan was in camp, and lengthy discussions were held concerning the nature of the formation and what it indicated. No definite conclusions have been reached as yet, consequently it is not possible to date the period of occupation.

E. G. Cassedy, illustrator of the Bureau of American Ethnology, joined the party in August and made a survey of the site. The map which he prepared, on a scale of 100 feet to the inch with 5-foot contour lines, will serve as a valuable graphic reference for discussions on the changes that have taken place in the terrain since the hunters of the extinct bison camped in that locality.



GENERAL VIEWS OF THE LINDENMEIER SITE

Top picture is toward the south. Deep pit in bank of ravine to right of car; arrow indicates car. Bottom view is toward the east.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 94, NUMBER 4

A FOLSOM COMPLEX

PRELIMINARY REPORT ON INVESTIGATIONS AT THE LINDENMEIER SITE IN NORTHERN COLORADO

(WITH 16 PLATES)

BY
FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

(PUBLICATION 3333)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JUNE 20, 1935

Smithsonian Miscellaneous Collections
Vol. 94, No. 4

A FOLSOM COMPLEX

Preliminary Report on Investigations at the Lindenmeier Site in Northern Colorado

By FRANK H. H. ROBERTS, JR.

ERRATA

On page 32, paragraph 3, lines 3 and 4 should read as follows:

the fox (*Vulpes velox*), the wolf (*Canis nubilus*), and the rabbit (*Lepus townsendii campanius*). Unfortunately, none of these throws . . . . .

A FOLSOM COMPLEX

Preliminary Report on Investigations at the Lindenmeier Site in Northern Colorado

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

(With 16 Plates)

INTRODUCTION

Investigations at the site that yielded the first definite complex of stone implements attributable to so-called Folsom Man came as the culmination of an interesting series of events that began in May 1934. In that month D. I. Bushnell, Jr., collaborator in anthropology, United States National Museum, discovered in two collections gathered from various parts of Virginia examples of the type of projectile point which has been called Folsom. Announcement of this fact was made by the Smithsonian Institution in one of its press releases. The article, with photographs of the specimens, was printed in slightly revised form in the Literary Digest for June 9, 1934. This notice loosed a veritable flood of letters, and queries poured in from collectors all over the country. There was some confusion about what constituted a Folsom point, and the editors of the Digest felt that a second article, one describing its characteristics in detail, was advisable. In response to a request from them the writer prepared a statement which appeared in the issue for July 28. The latter brought letters from many parts of the United States from people who had examples of the Folsom type.

Among the letters were several which were received indirectly. Maj. Roy G. Coffin, professor of geology at Colorado State College, Fort Collins, had on two occasions, prior to the Digest articles, written to Dr. John B. Reeside, Jr., geologist in charge, section of stratigraphy and paleontology, United States Geological Survey, concerning a site in northern Colorado. At that place he and a brother had found a considerable number of Folsom points, several other kinds of chipped tools, and indications that the implements had been made on the spot. Following the appearance of the second Digest article, Major Coffin again wrote to Dr. Reeside. The latter brought the correspondence to the attention of Henry B. Collins, Jr., division of anthropology, U. S.

National Museum, and he in turn transmitted the information to the Bureau of American Ethnology. Several letters were exchanged between the writer and Major Coffin, and as a result of the correspondence it was decided that a first-hand inspection of the site was advisable. In September the writer was sent to Fort Collins. The owner of the land, William Lindenmeier, Jr., gave permission for a series of investigations, and preliminary prospecting was started.

The site is north of Fort Collins, Colo., just south of the Wyoming line. It was first discovered in 1924 by Judge C. C. Coffin and his son A. L. Coffin. Since then they and Major Coffin, with various friends, have visited it from time to time and have collected numerous specimens. When the writer went to Fort Collins, they had gathered 83 points or portions of points and about the same number of other artifacts. From the very beginning of their finds the Coffins were impressed with the fact that all of the points picked up at this location differed from the usual Indian arrowheads which are so abundant in that general region. Although they were convinced that the points constituted a distinct type, they were not aware of their true significance until informed by Dr. E. B. Renaud, of the University of Denver, that they were Folsom points.

In the summer of 1930 Dr. Renaud and a number of his students, under a project sponsored by the Smithsonian Institution Cooperative Fund, the University of Denver, and the Colorado Museum of Natural History, were making a survey of local collections and of former village sites in Colorado and adjacent regions. Their purpose was to plot distribution maps for various types of implements, with the places where they were found. It was during these investigations that the Coffin series was noted.[1] In June 1931 Dr. Renaud visited the location from which the artifacts came, and he describes it briefly in one of his reports.[2] No digging was done, but portions of two Folsom points were picked up from the surface at that time. The Coffins continued their visits intermittently and added specimens to their collections. Most of the material was picked up from the surface, but a few pieces were scratched out of the soil. No extensive work was attempted until the autumn of 1934.

The place where the points and other implements were found by the Coffins is a denuded area approximately 70 by 150 yards in extent. The bulk of the material came from a small section covering only about 30 square yards. The surface over a greater portion of this site

[1] Renaud, 1931 a, p. 17.

[2] Renaud, 1932 a, pp. 27-28.

is the top of a hard, compact layer of grayish earth. The artifacts recovered from it had undoubtedly been in top-level material which was eroded away by wind and water. The implements, because of their weight, had remained until picked up. In some places, there remained portions of the sand, gravel, and nodule layer which had overlain the compact deposit, and a few objects were found on the contact line between the two. This part of the site did not offer any particular inducements for digging, especially if it was desired to find material in situ. At the close of the first day's inspection the writer was not sanguine over the prospects for getting information beyond that already obtained by Judge Coffin and Major Coffin.

On the second day, however, when the writer, with Judge Coffin and his son, was exploring the adjacent terrain, the Judge picked up a portion of a Folsom point along the bank of a ravine which cuts through the terrace some distance above the original site. Close inspection of the precipitous bank in the vicinity of this find revealed an undisturbed and intact layer of midden material 14 feet below the present ground level and 12 feet above the bed of the gully. A brief investigation demonstrated that the deposit, which is a quarter of a mile away from the spot where the majority of the Coffin specimens was found, was a likely place for excavation. Work was started and continued through the month of October and into the first part of November. Some digging was done at other portions of the site, but the major activity was restricted to the deep pit in the gully bank where most of the specimens described in following pages were found.

The type of point called Folsom has been known for a long time. Variations of the form have been found from the Rockies to the Atlantic, from southern Canada to the Gulf of Mexico. It is represented in collections in numerous museums and in at least one case has been called by another name, the Seneca River point. Except for a few instances,[3] it did not attract particular attention despite its peculiar characteristics. This was in part due to the fact that most of the examples were surface finds. Its true significance was established in 1927, and the interest focused upon it brought to light many which had previously passed unnoticed.

Because of a certain amount of confusion and misunderstanding concerning the original Folsom finds, a brief review of the subject is germane to the present discussion. In the summer of 1925 Fred J. Howarth and Carl Schwachheim of Raton, N. Mex., both now de-

[3] Beauchamp, 1897, figs. 13, 14, p. 21. Brown, 1926, fig. 45, p. 138. Thruston, 1890, fig. 139, pp. 231-232.

ceased, notified Director J. D. Figgins of the Colorado Museum of Natural History, Denver, of a bone deposit which they had found in the bank of an arroyo on the upper sources of the Cimarron River near the town of Folsom in eastern New Mexico. Samples of bone sent to the museum indicated that the remains were those of an extinct species of bison and of a large deerlike member of the *Cervidae*. Prospects for fossil material were so promising that the Colorado Museum sent a party to the site in the summer of 1926. During the course of the excavations, carried on under the supervision of Frank Figgins and Mr. Schwachheim, parts of two finely chipped projectile points were recovered from the loose dirt at the diggings. Near the place where one of them had been dislodged a small, triangular piece of "flint" was found embedded in the clay surrounding an animal bone. This fragment was left in the block of earth, and when the latter was received in the laboratory at Denver, the dirt was carefully cleaned away from the bit of stone. It appeared to be from the same material as one of the points, and close examination showed that it actually was a part of the point. This evidence seemed unquestionably to demonstrate that here was a definite association between man-made objects and an extinct bison.[4]

Director Figgins was so impressed with the find and was so thoroughly convinced that it was of importance to students of American archeology that he took the points with him that winter when he visited several of the large eastern museums on paleontologic business. In most places his announcement was courteously yet skeptically received. One authority on stone implements marveled at the quality of workmanship that the specimens exhibited and even remarked that they were reminiscent of the finest examples from Western Europe. He was doubtful, though, of the trustworthiness of the association. He thought that it could perhaps be attributed to an accidental mixing of material. Others said that the points had no significance because they could be duplicated in existing collections. At a few museums, notably the American Museum of Natural History, Mr. Figgins was urged to continue the work in the hope that additional evidence could be obtained.

The Colorado Museum again sent a party to Folsom in the summer of 1927 and had the good fortune to find additional points. One of these was noted before it was removed from the matrix, even before it was completely uncovered. Work was stopped immediately on that part of the excavation, and telegrams were dispatched to various

[4] Cook, 1927. Figgins, 1927.

museums and institutions inviting them to send representatives to view the point in situ. The writer at that time was attending the first Southwestern Archeological Conference at Pecos, N. Mex., and, upon receiving notice of the find and travel instructions from Washington, proceeded to Folsom. Arriving at the fossil pit, on September 2, he found Director Figgins, several members of the Colorado Museum board, and Dr. Barnum Brown, of the American Museum of Natural History, New York, on the ground. The point, which became the pattern and furnished the name for the type, had just been uncovered by Dr. Brown. There was no question but that here was the evidence of an authentic association. The point was still embedded in the matrix between two of the ribs of the animal skeleton. In fact it has never been removed from the block, which is now on exhibit in the Colorado Museum at Denver. On returning to Raton, N. Mex., that evening, the writer telegraphed to Dr. A. V. Kidder at Pecos and urged that he visit the site. Dr. Kidder arrived 2 days later, and he and the writer drove out to the bison quarry. After the whole situation had been carefully studied, it was agreed that the association could not be questioned. Furthermore, it was ascertained that the points were totally different from the ordinary types scattered over that portion of the Southwest.

At the meeting of the American Anthropological Association held at Andover, Mass., in December of that year Dr. Barnum Brown and the writer reported on the Folsom finds. There was considerable discussion of the subject, and although many agreed that the discoveries were important, there was still a general feeling of doubt. Numerous explanations were offered to show that the points might have gotten into such an association without actually being contemporaneous with the bison remains. Several mentioned that points of that type were numerous in collections from certain mound sites, from village sites in New York State, and elsewhere, and for that reason they could not be very old. Others insisted that, although they accepted the conclusions on the genuineness of the finds, there must be some mistake about the antiquity of the animal remains.

The summer of 1928 saw the American Museum of Natural History and the Colorado Museum cooperating at the Folsom site. The expedition was under the leadership of Dr. Barnum Brown, who was assisted by several graduate students in anthropology. The latter were under the general supervision of Dr. Clark Wissler. Additional points and bison skeletons were found, and telegrams reporting the discoveries were sent to various institutions. This time numerous special-

ists—archeologists, paleontologists, and geologists—rushed to see the evidence. The consensus of the informal conference held at the site was that this constituted the most important contribution yet made to American archeology. Some of the most skeptical critics of the year before became enthusiastic converts. The Folsom find was accepted as a reliable indication that man was present in the Southwest at an earlier period than was previously supposed.

In subsequent years there has been considerable activity on the part of those interested in tracing the distribution of the type of point found there. Some have endeavored, without marked success, to find new locations where further evidence could be obtained in situ. Others have been content to make surveys showing the occurrence of the type. There have been a few significant discoveries, but most of the information thus far available concerns material found on the surface. The latter is of value from the standpoint of distributional studies, as an indication of likely spots for intensive work, and in showing local variations in the type. Yet, so far as chronological significance is concerned, it has added little to the knowledge gained at Folsom. The most important contributions have come from sites in New Mexico, where E. B. Howard, of the University of Pennsylvania Museum, has been engaged in a series of investigations. In a cave in the Guadalupe Mountains in the southeastern part of the State he found a Folsom point in conjunction with musk ox and an animal of the musk ox group.[5] The musk ox is a cold-climate animal and when found as far south as New Mexico, is generally considered good evidence of an ice-age fauna. The association was of further significance because it occurred in a stratum underlying a level containing Basket Maker material. The latter belongs to the oldest definitely established horizon in the culture-pattern sequence in the Pueblo area of the Southwest. This is a good indication that the points antedate the Basket Makers.

Near Clovis, N. Mex., Mr. Howard has been exploring a site where large numbers of chipped implements, including Folsom specimens,[6] and bones of extinct species of animals are found together. The chief difficulty at this location, however, is that the material occurs in what are known as "blow-outs," places where all of the top soil has been carried away by action of the wind. For that reason accurate indications on associations are hard to obtain. The finds are in old lake beds, and the geologic evidence is of significance. At the time of the pres-

[5] Howard, 1932.

[6] Anonymous, 1932; 1933. Howard, 1933; 1934, fig. 1.

ent writing, official reports on the Clovis work have not been published; hence, reference can be made only to the investigations.

The exinct bison from the fossil pit at Folsom, *Bison taylori*[7] (*Stelabison occidentalis taylori* and *Bison oliverhayi*[8]), are considered to be Pleistocene forms, animals that were living in the glacial period. This fact, coupled with the finding of points in association with bones of the musk ox and of other extinct bison in additional localities, furnishes the basis for the conclusion that the Folsom points represent considerable antiquity. This belief is substantiated by the fact that at a number of sites points bearing certain characteristics of the true Folsom type, yet not definitely assignable to that class, have been found with remains of extinct species of animals. One of the sites best illustrating this phase of the problem was that at Dent, Colo., where two points, one of which is decidedly Folsomoid, came from a deposit containing mammoth bones.[9] Several pits in Nebraska and Kansas have yielded points, in some cases with mammoth bones and in others with bison bones.[10] Near Colorado, Tex., an articulated skeleton of an extinct bison and some chipped points were recovered from a reputedly Pleistocene deposit.[11] Although the majority of the blades in this group of finds are not primarily Folsom in type, the conditions under which they were discovered tend to substantiate the Folsom evidence for an early occupation of the New World. In the latter connection, though they have no bearing on the Folsom problem proper, might be mentioned an association of man-made objects and traces of the ground sloth in Nevada,[12] and human bones with sloth remains near Bishop's Cap, N. Mex.[13] These occurrences are additional contributions on the "antiquity of man" in the Southwest. Whether all of this evidence from the various places mentioned actually dates man in the closing days of the Pleistocene, indicates his presence at the beginning of the post-glacial period, or demonstrates a later survival of ice-age animals is a phase of the problem which the geologist and paleontologist must solve.[14] Some insist that the evidence unequivocally proves that man was here in the Pleistocene, others that he came during the transition between the glacial and

[7] Hay and Cook, 1930.

[8] Figgins, 1933 b.

[9] Figgins, 1933 a.

[10] Bell and Van Royen, 1934. Schultz, 1932 (contains lengthy bibliography).

[11] Figgins, 1927.

[12] Harrington, 1933.

[13] Bryan, 1929. Thone, 1929.

[14] For a discussion of this subject see Antevs, 1935.

Recent periods, but was not actually here in the ice age. All agree that more data are essential. Archeologists generally concede that the points belong to the earliest phase of aboriginal culture yet discovered in America.

Distributional studies have demonstrated several facts. The most significant of these is that there are two main classes of Folsom type points: the true Folsom, and a larger, more generalized form embodying most of its characteristics but not exhibiting the skilful workmanship or mastery of the stone-chipping technique apparent on the true example. Present evidence is that the true Folsom is restricted to the strip of terrain, known as the High Plains, extending along the eastern slopes of the Rockies. The other form not only occurs in the High Plains but is widely distributed across the eastern portion of the United States.[15] There are several places about which the latter seems to center, notably the Finger Lakes section in New York State, in Ohio, Tennessee, and southern Virginia. Sporadic examples have come to light in various localities in practically every State east of the Rockies and in portions of southern Canada. The problem of distribution for the eastern area received considerable attention several years ago from Alfred Kidder, II, then a graduate student at Harvard University. E. B. Howard began his studies at about the same time, and when Kidder's interests were turned to other fields, his unpublished manuscript and all of his information were turned over to Howard. The latter is still actively engaged in the study.

From the letters, photographs, and actual specimens sent to Mr. Bushnell and to the writer, following the publication of the Digest articles and press notices of the work in Colorado, much more information has been added to the data on the occurrence of the eastern type. This work is still being continued, and a tabulation of the results and a consideration of their significance will be incorporated in a larger and more comprehensive study of the subject. It is in this connection that investigators must face the problem of whether the generalized form indicates an earlier phase which reached its perfection in the true Folsom or whether it represents a degenerate and later variation. Another aspect of this phase of the study is the diffusion of the type. There is the possibility that it traveled south along the cordillera, then swept east and north. On the other hand the two forms may represent off shoots from an original basic type which spread along two separate lines, one skirting the eastern slopes of the mountains, the other moving eastward and then south.

[15] Howard, 1934, pp. 13-14.

Studies of distribution in the area adjacent to the Rockies are being carried on by Dr. Renaud and several of his students. Others are interested in the problem but are not actively engaged in the work. In the course of his surveys Renaud noted a type of implement which, in some districts, apparently occurs in conjunction with the Folsom points. Because the largest and finest series of this other type to pass under his observation was in an extensive collection at Yuma, Colo., he named it the Yuma type.[16] Yuma and Folsom points are found together at many sites as surface material, and their association no doubt has some significance, although just what it may be is not now apparent. On the basis of typology Renaud considers the Yuma older than the Folsom.[17] Others, notably Mr. Figgins,[18] do not agree. The age of the Yuma type has not been satisfactorily established, though one find of a debatable nature is frequently cited as proof of the antiquity of the form,[19] and another is still under discussion.[20] Since neither the Folsom pit nor the Lindenmeier site yielded Yuma points, further consideration and detailed descriptions of them are beyond the requirements of this paper. It was deemed advisable to mention them because the two names so frequently appear together. Persons interested in the Yuma types will find them described in Renaud's papers.

The importance of the Lindenmeier site lies in the fact that for the first time traces of an occupation level which can be assigned to a group of Folsom men have been brought to light. Whereas prior to the work in northern Colorado the only indications of this presumably early hunting people were typically chipped stone points, there is now a definite complex of associated implements. The last few years have been marked by much loose talk and writing about the "Folsom Race," the "Folsom Culture," and "Folsom Man," when actually all that was known was the characteristic point. From a strict anthropological point of view it is still incorrect to speak of "Folsom Culture" because the remains so designated probably should be considered only as one aspect of a basic, widespread early hunting pattern which may have extended across the eastern half of the continent. So far as Folsom Man himself is concerned, he is still persona incognita. No skeletal material that can properly be assigned to him has to date been discovered. Recent reports of a Folsom Man in Minnesota

[16] Renaud, 1932 b, p. 1.

[17] Renaud, 1931 a, p. 15; 1934 b, p. 2.

[18] Figgins, 1934.

[19] Cook, 1931.

[20] Barbour and Schultz, 1932. Bell and Van Royen, 1934. Figgins, 1934.

cannot, in the opinion of the writer, be accepted as evidence of such a find, because published illustrations of the points found with the human bones indicate that they are not Folsom, either of the true type or of the widely distributed generalized form. Nor are they Yuma, although identification of the skeleton as Folsom Man is based on the deduction that the points are Folsom in outline and Yuma in flaking, and hence intermediate in time and development between the two.[21] In view of the status of the Yuma, as discussed in a preceding paragraph, a form midway between it and the Folsom is not particularly significant. The Minnesota man may represent a local aspect of the general hunting culture of the period indicated by Folsom; he may even be older. That is beyond the question here at issue, namely, that present evidence does not show him to be Folsom Man.

Not only has the Lindenmeier site furnished a variety of implements for the Folsom horizon, but in addition there are numerous stone flakes,—typical workshop debris. These occur in the deposits with the tools and give mute but accurate evidence of much of the technique employed in the manufacture of the implements. Furthermore, the numerous spalls, nodules, and large cores indicate that the stone working was done on the spot. Considerable raw material was available in the neighborhood, and this may have been one of the attractions which led to the occupation of the site. Other items influencing this choice probably were the presence of a large spring and an abundance of game animals. The midden deposit contained quantities of cut and split bones. This material is very scrappy in its nature, but nevertheless it has been possible to identify some of the animals represented. Two of the species contribute support to the belief that the Folsom complex represents an appreciable antiquity. There is also the chance that better bone specimens will be obtained there and that more animals will be represented, thus increasing the information on that phase of the problem. The site holds possibilities from a geologic point of view, and it is hoped that careful studies by a number of specialists will give an accurate indication of the probable age of the deposits.

Great credit is due Judge Coffin and his son for the discovery of this site and to the Judge and his brother, Major Coffin, for their efforts to protect it and bring it to the attention of the scientific world. Their whole-hearted cooperation during the investigations by the writer facilitated the work and made possible better results than would otherwise have been attained in so short a time. A. L. Coffin assisted

[21] Anonymous, 1934 a; 1934 b. Jenks, 1934; 1935, pp. 7-11.

in the digging throughout the period that the excavations were being made. The kindness of Mr. Lindenmeier in granting permission to work on his land is deeply appreciated.

THE LINDENMEIER SITE

The Lindenmeier site, where the specimens described in the following pages were found, is 28 miles (45.062 km) north of Fort Collins, Colo., and 1¾ miles (2.816 km) south of the Wyoming line. Specifically, it lies in sec. 27, T. 12 N., R. 69 W., sixth principal meridian. The site is on a terrace (pl. 1, frontispiece) above the valley of an intermittent tributary to a series of creeks which ultimately join the South Platte River. Whether this is a part of the old terrace system of the Platte, which is being extensively studied by geologists in the region farther east, is still to be determined. The formation is generally called the White River. It consists of a bed of grayish clay covered with a conglomerate composed of sand, gravel, and occasional large boulders. The clay is a Tertiary deposit, Oligocene, with a possible admixture of some volcanic ash. The capping conglomerate is indeterminate in age. It may be rather old, or it may be comparatively recent.

The Lindenmeier site presents an interesting geologic problem in the question of the wearing away and building up of the terrain. The man-made material and animal bones occur in a dark soil layer which rests on the clay bed and underlies the conglomerate. A tentative reconstruction of the topography at the site, based entirely upon the writer's interpretation of conditions and not upon observations by a competent geologist, suggests that at one time there was a short, narrow valley lying between a series of conglomerate-topped ridges, a situation comparable to that existing today at no great distance above the archeological location. (See pl. 2, fig. 1.) The valley bottom consisted of a soil layer, several inches in thickness, resting on the Oligocene deposit. Here and there were small ponds or marshy places, as indicated by the siltlike strata of dark soil in depressions in the clay bed. The human occupants of the valley lived on top of this soil layer. As a result of their continued presence, numerous objects associated with their daily round of life—charcoal and ashes from their fires, bones from the animals that supplied the meat for their meals, stone chips from the implements that they made, broken tools and other artifacts—were scattered over the surface. These in time became embedded in the rising soil level, were subsequently buried by additional soil layers after the people departed, and eventually were covered by

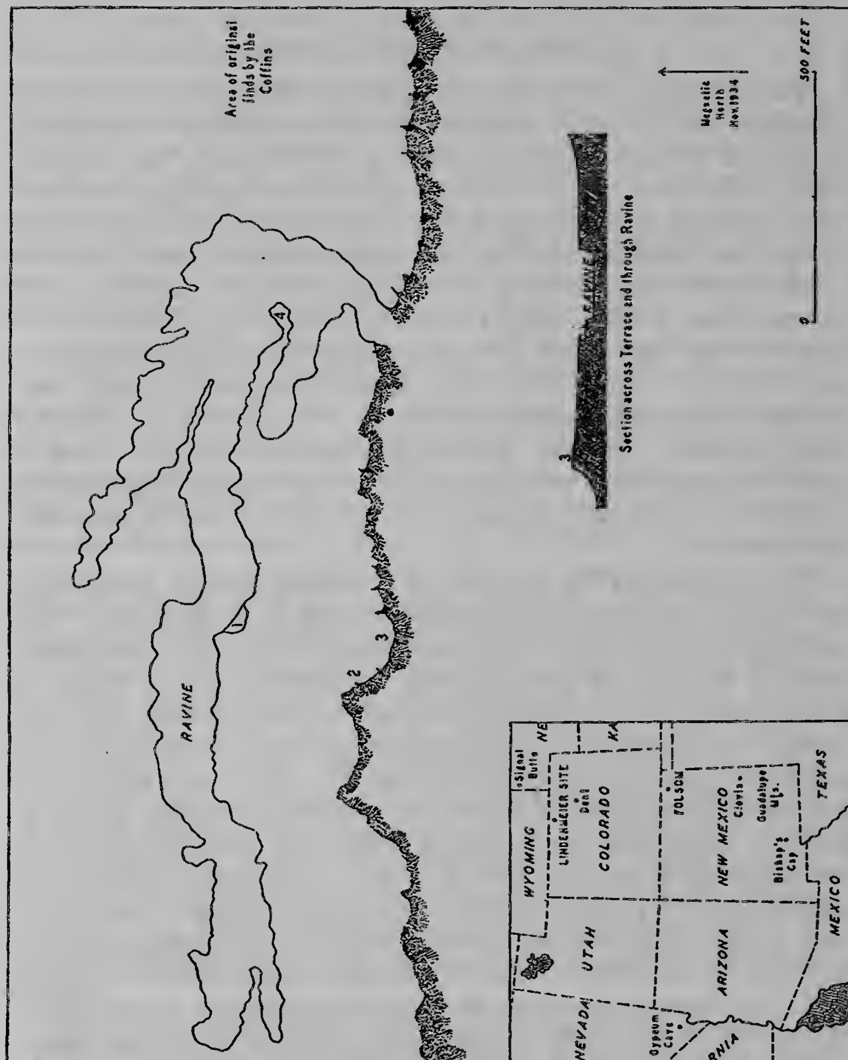


FIG. 1.—Sketch map of the Lindenmeier Site. 1, location of deep deposit; 2 and 3, places where bones and "flints" were found; 4, implements obtained at this spot. Insert shows location of the site with respect to other finds indicative of considerable antiquity.

the present overburden when sand, gravel, and boulders were swept down into the valley from its bordering hills. Later, water, coursing its way down the hillsides and along the valley, cut the gully in whose banks the midden deposit was revealed.

The present ravine is only one of several channels which have from time to time been worn in that portion of the terrain. Traces of other water courses which did not cut so deeply into the valley fill are apparent in the sides of the gully. One old channel passed directly over the top of a portion of the layer in which most of the stone and bone material was found. It did not wear its way down into the old soil line but stopped a few inches above it and then began to build up. It gradually became filled, until, so far as surface indications are concerned, it was completely obliterated. The direction of the old channel at this point had been almost at right angles to the now existing gully. In character the former suggests a meandering stream, one which probably continued to the lower end of the valley a mile or so east of the mouth of the channel of today. The filling of the stream bed may have resulted from damming by alluvial gravels washed in from one of the side canyons near its mouth. Considerable time is probably represented by all this action, although conditions in the West are such that channel cutting, filling, and shifting may occur in a relatively short period of years. Other factors indicate that the process here could not have been extremely rapid because ridges from which some of the valley fill was eroded have since completely disappeared, having been weathered away in the opposite direction. This is shown by the fact that the soil layer—the artifact-bearing stratum—topping the clay bed is still on the upslope, where it appears along the edge of the terrace above the broad valley to the south of the site. The complete erosion of the ridge transformed the level from a valley bottom to what may possibly be considered to be a terrace.

One aspect of the problem which is of interest, although it bears only indirectly on the archeological factor, concerns the original scouring of the valley bottom and removal of material down to the Oligocene stratum. Whether this resulted from action by mountain glaciers, by water from them, or from some more recent agent is one of the many phases of the subject which geologic studies may explain. Should it be established that the Oligocene deposit was laid bare at the time of the great mountain glaciers, which are considered to have been contemporaneous with the Wisconsin ice sheet, a significant inference could be drawn, namely, that makers of the implements arrived on the scene not long after the retreat of the ice, since evidence of their

2

presence occurs immediately above the eroded surface. This would place the occupation of the locality at the beginning of the present geologic period. Although speculation of this nature suggests interesting possibilities, it must be borne in mind that it is only conjecture and that careful examination of the deposits by specialists may result in entirely different conclusions. The chief purpose of this supposititious reconstruction is to call attention to some of the questions raised by conditions at the site.

Preliminary prospecting indicated that the main concentration of archeological material occurs in the strip of land lying between the present gully and the edge of the terrace (fig. 1). The area is approximately 250 yards (228.6 m) long by 100 yards (91.44 m) wide. The artifact-bearing stratum varies in depth below the surface. Along the edge of the terrace its average depth approximates 2 feet (60.96 cm), increasing rapidly toward the bank of the gully, where it is 14 feet (4.267 m) below the present surface at the place where most of the digging was done. (See pl. 2, fig. 2.) It is 6 feet (1.828 m) down from the top at the mouth of the ravine. The difference in depth between the upper and lower ends along the bank is due not so much to variation in the old soil line level as to the slope of the present surface. Digging at a number of places, both along the edge of the terrace and in the sides of the ravine, yielded stone implements and broken animal bones. The specimens occurred in greatest numbers at the deepest point, however, and for that reason most of the preliminary work was restricted to that portion of the deposit. The material at this location suggested a midden or refuse layer, whereas that from other portions of the site was more of the nature of chance accumulations. The objects, bone and stone, were found for the most part just above the clay stratum in a layer 6 inches (15.24 cm) to 1 foot (30.48 cm) in thickness (pl. 3). Some were lying flat at the line of contact between the layers, others extended down into the top of the clay as intrusions.

The deep level, where most of the work was done, seemingly constituted the peripheral vestiges of one of the depressions in the top of the clay bed, as mentioned in a preceding paragraph. It suggested that the material had been deposited along the edges of a shallow pond or a marshy spot. The main portion of the old depression was washed away when the present ravine was formed. A wedge-shaped excavation was driven into the bank following along the top of the clay bed. Because of the large amount of overburden to be removed, the necessity for extremely careful digging, and the short time available for

the investigations, only a small area was uncovered. It measured 53 feet (16.154 m) along the ravine, extended into the bank 38 feet (11.582 m) on one side and 26 feet 6 inches (8.077 m) on the other. In view of the small size of the excavation the number of specimens obtained was gratifying both as to quantity and variety.

In the following descriptions of the various kinds of tools found at the Lindenmeier site, only the more general features will be considered. A detailed typological study, discussions of the technique of manufacture, and comparisons of this material with similar objects from sites not necessarily Folsom in nature are not advisable at this time, since further excavations are planned. Additional and more comprehensive evidence will no doubt be available when the investigations are completed. The various kinds of stone represented by the implements in the present group are: Chalcedony, jasper, chert, quartzite, petrified wood, moss agate, geyserite (rare), and white sandstone. The chipper's debris—flakes, cores, and nodules—also exhibits the same variety. The most popular " flints " were chalcedony and jasper. (The writer does not believe it necessary to go into the question of flint and flintlike materials in the present discussion. Where the term flint is used, it refers only to the implements, not to the particular stone involved.) The other kinds of material found in the region do not flake and chip as readily, nor do they permit as high a degree of workmanship. The recent Indians inhabiting the district made greater use of quartzite and geyserite.[22] The sandstone objects from the old horizon were not cutting or penetrating implements, but rubbing and polishing stones.

POINTS

True Folsom points occur in two forms. The better known variety, based on the first example found actually in situ at the Folsom pit, is a thin, leaf-shaped blade. The tip is slightly rounded, and the broadest part of the blade tends to occur between the tip and a line across the center of the face (fig. 2, A, a, b). A typical feature is a longitudinal groove or channel extending along each face, C, about two-thirds of the length. These grooves produce lateral ridges paralleling the edges of the blade. A cross-section of the object gives a biconcave appearance as shown in the diagram. The base is concave,

[22] Major Coffin has studied extensively the tools made by the different Indian groups which inhabited the Fort Collins area at various times and has determined most of the sources for the materials used. A summary of his findings appears in Renaud, 1931 b, p. 61.

the concavity varying in outline on different specimens, and there are frequently long, sharp base points often called "ears." Between the edges of the blade and the lateral ridges produced by the central grooves is a more or less fine marginal retouching, a secondary removal of small flakes. Points in this group tend to be somewhat stubby, as they are broad in proportion to the length. The second form, B, was present in the type site but is rarely mentioned in discussions because of the general lack of information on the subject. It is also a thin,

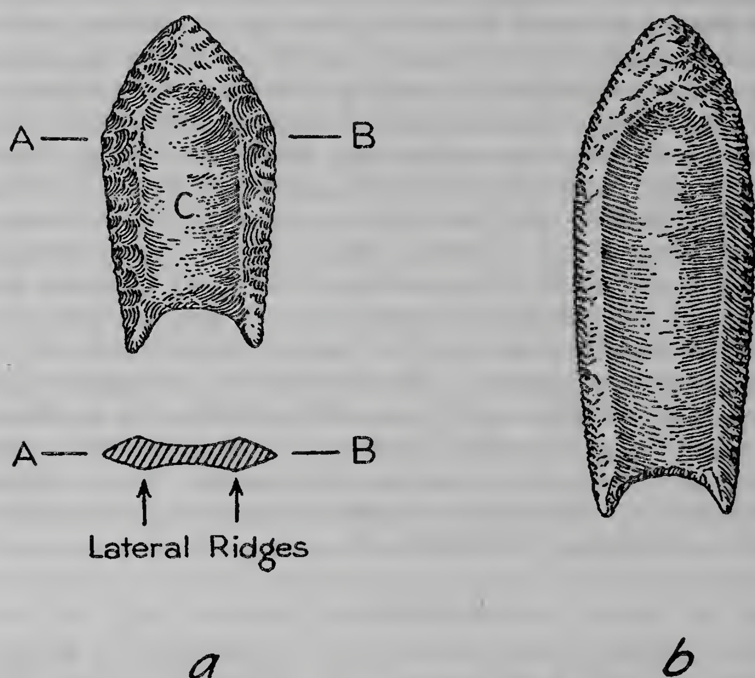


Fig. 2.—Two forms of the Folsom type point.

leaf-shaped blade with characteristic fluting on the faces. In contrast with the first form, however, it is long and slender in outline and has a tapering rather than a rounding tip. The type of base for this second form is not known from Folsom, as the specimens found there were broken, the butt ends being missing. Similar points from the Lindenmeier site have concave bases. Hence it is permissible to assume that the same was true for the specimens from the type site. It is quite possible that some of the broken bases from Folsom were from B form blades, although there is nothing to substantiate that assumption.

The various features that characterize the Folsom points may be found singly or in different combinations on specimens originating in several sections of the country, but unless all are present on each individual artifact it cannot be considered as a true example of the type. Failure to observe this fact has led to some confusion and misunderstanding. Mere concavity of the base or leaflike shape does not constitute a Folsom point. The groove is an essential feature. Whether grooves on both faces should be insisted upon is a debatable question, because in at least one of the specimens from the original site it was present on only one face. This point, or rather portion of a point, was picked up by Mr. Howard from the dump at Folsom during the summer of 1934. Except for the absence of the fluting on one side, it is in all respects characteristic of the type. It is the only example from that location which was made from quartzite, and as that material is so difficult to work, it is possible that the groove was omitted for that reason. One example from the B group at Folsom, which has been pictured a number of times, seemingly has a groove on but one side.[23] As a matter of fact the specimen in question shows that it did have a groove on each face, though one was unusually short and most of it was lost when the butt end was broken off. Just a trace of the upper end of the channel is to be observed. That so short a flake was removed was due, as the specimen clearly shows, to a flaw in the stone. This caused the flake to turn out rather close to the base instead of farther along the face. A number of fragmentary points from the Lindenmeier site have the channel on only one side. Most of these appear to be implements broken and discarded before completion, however, and for that reason are not a good criterion. In view of the evidence from Folsom, and despite the contradictory nature of such a statement, it may be said that a true Folsom point should be fluted on both sides, but an otherwise typical example may occasionally have the feature on only one side.

The rarity of perfect specimens has been commented upon in various articles on the subject of Folsom points. A large majority consists of broken examples. There was only one complete blade in the group of 19 found at Folsom, and the proportion at other sites has been even smaller. This may be attributed, as has frequently been suggested, to the brittleness caused by the fluting. The removal of the longitudinal flakes so thinned the points that they became extremely fragile. The purpose of the grooves is not known. A number of explanations have been made, and any or all may apply. Perhaps the

[23] Figgins, 1927, fig. 3.

most logical is that they were to facilitate hafting the head to the shaft of the spear or arrow. Other interpretations are that they were to reduce the weight, to improve the penetrating qualities, to permit the point to break off in the animal, to allow the head to slip out of the fore-shaft, and to promote bleeding. It is possible that a number of such ideas were contributing factors in the perfection of the type.

With the exception of two specimens, all the points or portions of points found at the Lindenmeier site are of one or the other forms of the true Folsom type. One variant is an extremely thin example which would not have permitted the removal of such flakes (pl. 5, *i*; 6 *i*). In its general outline and style of chipping it indicates a relationship to the group, but nevertheless, it cannot be considered a Folsom point. It probably represents a different type, because similar points have been found at Clovis and other sites. A single example is not sufficient for definite conclusions, but there may be some significance in the fact that this specimen was found on top of the old soil layer—not down in it as were most of the true forms. The other point that does not conform was made from a scrap flake not primarily intended for such use, and hence was not properly shaped in the beginning (pl. 7, *h*; 8, *h*). This object came from the deep deposit and was in association with typical Folsom material. It is too indeterminate in character to be considered other than an aberrant form. Furthermore, since the base edge is chipped in a fashion suggestive of a scraper rather than a projectile point, it is possible that it was one of the former.

From the time that the Folsom type and its longitudinal grooves first attracted attention there has been considerable discussion about the technique employed in the removal of the long flakes. Some have insisted that they must have been dislodged before the blades were worked down to their characteristic shape. The writer has maintained from the beginning, as have several others, that the major part of the shaping constituted the initial stage, and that the long flakes were then removed.[24] The final touch was the secondary chipping between the lateral ridges and the edges.[25] This was suggested by the fact that the longitudinal channels cut through the smaller cross grooves left by the primary shaping process. Another indication was the " hinge fracture " on the ends of broken specimens. This resulted from a reverse action on the part of the flake. Instead of turning out, it turned in and went through the blade, breaking off the tip and leaving a smooth, rounded end on the butt. There are several examples of

[24] Cook, 1928, p. 40.

[25] Renaud, 1934 b, p. 3.

this in the present collection. In one instance both the tip and the butt were found (pl. 7, *l*; 8, *l*), and another specimen exhibiting the feature has already been described in print.[26]

This proof was not sufficient to convince a number of the investigators; now, however, there is clear-cut evidence. The Lindenmeier site contributed portions of flakes which came from the longitudinal channels. The Coffins found a number of such flakes in their work, and several were obtained during the digging by the writer. Major Coffin expressed the belief that they were from the channels, and the additional specimens show this to be the case. In every instance the flakes are smooth on one side—the side that formed the groove in the blade—and flaked on the other (pl. 4). The latter surface was part of the face of a completely shaped point. Furthermore, fragments of blades broken in the process of manufacture and consequently discarded substantiate the conclusion. What may seem to be an exception to this procedure (although actually it is not) is occasionally noted. Some specimens suggest that use was made of a random flake which already had a groove on one side. With such material, all that was required was the shaping and fluting of the other face. But the same method was followed for the single side as in the making of a complete point. Examples of this nature are not common, however,

The technique of removing the long flake is not definitely known, but the scrap material from the midden gives some good clues. Both the fragments of the points and the pieces of channel flakes indicate that a hump was left in the center of the concavity when the base was chipped (fig. 3, *a*). This formed the " seat " for the implement used to eject the flake. That percussion, not mere pressure, was resorted to is evidenced by the definite bulbs of percussion on the flakes and by the reverse impressions in the bases of the points which had not been secondarily chipped. It would be extremely difficult to strike a nubbin as small as the " seat " with a hammerstone; hence it seems logical to suppose that the blow must have been an indirect one. A tool of bone or antler probably served as a punch to transmit the impact required to flip out the flake. Indirect percussion was employed by certain recent Indian stone chippers in making some of their implements,[27] and it may well have been part of the ancient technique. When the groove had been obtained on one side, the nubbin was retouched, if necessary, and the process repeated on the other side. The rechipping of the " seat " was no doubt partially responsible for the depth of the

[26] Renaud, 1934 b, p. 4.

[27] Holmes, 1919, pp. 295-296.

concavity and the length of the "ears." There is nothing to show whether the work was entirely that of a single individual or whether two were needed. It is quite possible that one held the point with the punch firmly seated at the proper spot on the nubbin while another gave a quick, sharp tap on the flaking implement with a hammerstone. This unquestionably would require skill on the part of both but probably would not be as difficult a task as though one person tried to do it alone. Present day experts in stone chipping may be able, through experimentation, to solve the problem of which would be the more efficient method. In a majority of cases a single, long flake was removed at a single blow. Occasionally the first attempt was not satis-

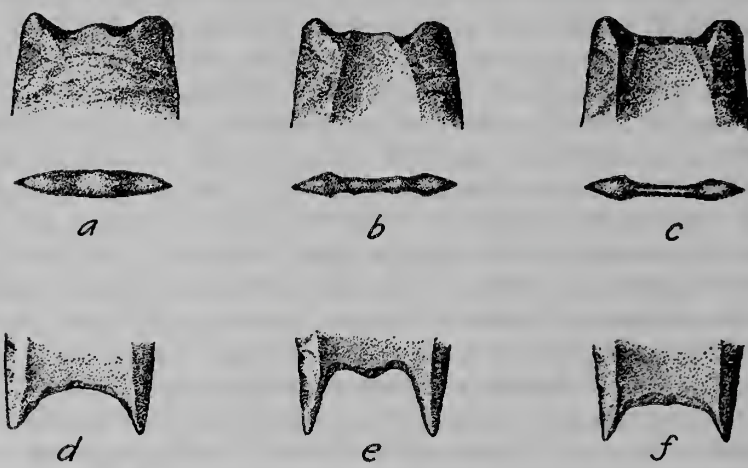


FIG. 3.—Stages in the removal of the channel flakes and three forms of base on Folsom points.

factory and a second try was made. Major Coffin has two flakes in his collection which show this clearly. The first one was rather short and very thin, the second thicker and much longer. The first fits perfectly into the groove in the second.

After the fluting was accomplished, the edges and base of the point were refined by secondary chipping. This is evidenced by the fact that those broken in the grooving process, and consequently not completed, do not have the retouch. Occasional specimens show an additional treatment in that the base and the edges for about one-third of the length of the blade were smoothed. Whether this was intentional or accidental is not known. This smoothness may have resulted from the hafting of the stone in a wooden or bone handle, or, as one writer has suggested, it may be due to a deliberate dulling of the edges to pre-

vent the cutting of the lashings used to fasten it to the shaft.[28] This feature is present on only a small proportion of the true Folsom points but is common on the generalized eastern forms. On an occasional specimen, one-third to one-half the length of the blade above the base, is a small notch in each edge. These probably were to facilitate the fastening of the point to a shaft.

The extent to which the base was subjected to the final retouching process determined the contour of the concavity—whether it was curved, figure 3, *d;* wavy, figure 3, *e;* or squarish, figure 3, *f*. In most of the specimens from the Lindenmeier site it is wavy, because the bulk of the material was broken and discarded before completion, but there are some which show entire obliteration of all traces of the flaker " seat." In his distributional and typological studies on Folsom points Renaud worked out the percentages of base types and found that the curved concavity predominated, although the squarish and wavy forms were a close second.[29] He describes the latter as separate base types, C-1 and C-2, but groups them together as C in his tables, so that it is not possible to determine the number of each. Since the squarish or C-1 form on the basis of typology is the most highly developed and represents the ultimate stage in the perfection of the technique, percentages might be significant. A site with a predominance of the C-1 forms could be regarded as representing a higher cultural level than one where the C-2 was the main form.

Most of the point specimens from the Lindenmeier site are fragmentary, and all but a few of the pieces are butt ends. The scarcity of tips was puzzling at first. Consideration of the problem led to the conclusion that the prevalance of basal portions was due to one factor, the replacing of damaged points. Because of their brittleness, many were no doubt broken by hunters in the chase—snapped off in the killing of game. The shafts of the spears or arrows, unharmed and still serviceable, were carried back to camp and fitted with new points, the broken pieces being tossed into the midden. The fragment remaining in the shaft would naturally be the butt end; hence the numbers in the deposit material. It may be mentioned in passing that there is nothing to indicate whether the points were used in arrows or spears. Present thought is that the bow and arrow was a late development in the New World and that the older cultures employed a spear and spear thrower. Without evidence in the matter, archeologists concerned with the Folsom problem have gone on the assumption that the points were used in a shaft hurled from a spear thrower.

[28] Renaud, 1934 b, p. 3.

[29] Renaud, 1934 b, pp. 8, 9.

Measurements for the size range of points in the present collection are unsatisfactory because of their fragmentary nature. In his tabulations on specimens studied in numerous collections, including both the generalized and the true Folsom types, Renaud has compiled the following figures: Length, 17 to 115 mm; width, 14 to 36 mm; thickness, 3 to 14 mm.[30] For the true forms the range is not as great: length, 17 to 75 mm, with a 45.41 mm average; width, 14 to 32.5 mm, with a 21.94 mm average; thickness, 3 to 6 mm, with a 5.38 mm average.

SCRAPERS

A large proportion of the specimens in the collection belongs to the scraper group. There are several varieties of this type of implement, and the tools exhibit different degrees of workmanship. Some have as minute and careful chipping as that to be seen on the finest projectile points, whereas others are extremely crude and rough, only the minimum of effort necessary to make a usable implement having been expended on them. Most of the scrapers belong to the curved-end type, the so-called "thumb-nail" or "snub-nosed" form (pl. 9). Next in order, from a numerical standpoint, are the side scrapers. In this group are tools with straight, convex, and concave scraping edges. There are some turtleback scrapers and a few implements difficult to classify because they combine several features.

The "snub-nosed" type has a number of different subforms, but all are characterized by one convex, carefully chipped end. The treatment of the other end and the edges, as well as of the lateral surfaces, varies. To make such an implement, a flake of stone roughly the shape of a trigonal pyramid was struck off from a larger core. For the simpler form of the tool this flake was chipped along the base to produce the typical, thick, rounded end. The cutting edge then received an additional chipping which made it very sharp (pl. 10, *a, b, c*). The other end was left untouched, the bulb of percussion caused by the blow when the flake was detached furnishing a satisfactory tip. The side edges were not chipped, nor was anything done to the faces or lateral surfaces. This form is triangular in cross-section. A second subform was similar to the first except that the side edges were worked. A still more refined implement, the third subform, was made by removing the ridge or top edge so that the cross-section became pentagonal instead of triangular. Some additional minor retouching on the lateral surfaces occasionally accompanied this feature. The

[30] Renaud, 1934 b, pp. 9-10.

two side edges were also chipped. The removal of several long flakes from the top produced a fourth subform, one with a quadrangular cross-section. The latter also resulted from the removal of a single, long, broad flake, which produced a fluting similar to that on the projectile points. On practically all of the pentagonal and quadrangular forms the smaller end, as well as both edges, was modified by additional chipping. Rarely was the ventral surface, the bottom of the tool and the side which came off the core, altered in any way.

A very elaborate classification could be made for the subforms of this type of scraper by segregating the different specimens according to the various combinations of features. For the purposes of this paper that is not essential, but in a more detailed study such a subdivision would be advisable, especially when the subject of comparisons is considered. The " snub-nosed " scraper was not peculiar to this horizon or locality. Forms of it are found on recent Indian sites in the general High Plains area and elsewhere throughout the country. By means of an elaborate typological grouping it may be possible to point out distinctions, to determine criteria for identifying early and late forms. Such an attempt will be deferred, however, until a larger series from the Lindenmeier site is available. The " snub-nosed " scrapers from this site vary in length from 21 to 25 mm, in breadth at the cutting edge from 25 to 30 mm and in thickness from 4.5 to 11 mm.

The side scrapers exhibit considerable range in quality, degree of finish, and the types of flakes used in their manufacture. Some are light in weight and paperlike in their thinness. Others are thick and heavy. Certain examples display careful dressing of the faces of the blade as well as minute and precise chipping along the edges (pl. 11). There are other specimens that are little more than rough flakes with chipping along one edge or only on a portion of the edge (pl. 12). In some cases part of the siliceous crust or outer covering of the nodule from which the flake was struck is still present. The purposes for which the tool was intended no doubt governed the amount of work expended in its shaping. As will be noted from the illustrations, several of the implements combine both the convex and concave blades on a single tool (pl. 11, *g*). Others have one straight edge and one convex (pl. 15, *n*), or a straight and concave combination. The carefully worked side scrapers range from 30 to 62 mm in length, 15 to 33 mm in width, and 2 to 4 mm in thickness. The rough-flake forms vary from 40 to 60 mm in length, 20 to 45 mm in width, and 7 to 12 mm in thickness.

The turtleback is an interesting form of scraper (pl. 15, *i, j*). In the strict sense of the word these objects are not true turtlebacks, inasmuch as they are faceted on only one side, the other being flat or slightly concave. This feature can be attributed to the fact that they were made from large, thick flakes rather than from complete nodules; consequently, it was necessary to shape them on only one side. The convex surface of such tools is characterized by large facets suggestive of the back of a turtle. The edges exhibit the fine retouch typical of most of the specimens of the entire complex. If it was not for the latter feature, many of the turtlebacks might be considered as discarded cores from which flakes had been removed to be used in making small implements. Or they might even be classed as blanks waiting the specialization which would make them tools. Specimen *i*, plate 15, has a length of 53.5 mm, a width of 49 mm, and a thickness of 18 mm. The measurements for *j*, plate 15, are: length 57.5 mm, breadth 41.5 mm, and thickness 14 mm.

There is no definite knowledge about the uses to which the side scrapers and turtlebacks were put, but their functions were no doubt manifold. They could have served for dressing hides, for removing flesh from bones, for cutting bones, for smoothing spear and arrow shafts. In short, they combine in one implement the qualities of a knife, an adze, a gouge, and an abrading or finishing tool. The scraper in its various forms was indispensable in the daily life of the later Indians, and this was no doubt true for the dwellers at the Lindenmeier site. The general character of the different kinds of scrapers is well illustrated by the examples shown in the photographs; hence, more detailed descriptions of their various peculiarities are not necessary at this time.

BEVEL-EDGED TOOLS

The implements of the bevel-edged type are generally triangular in outline with a small, rounded tip and two chipped edges. The base is smooth and the faces comparatively flat. These tools might well be considered as points, although not in the sense of projectile heads (pl. 11, *b*). Their characteristic feature is the beveled edges. In making such a tool the chipping was all done from one side so that the cutting edge slanted obliquely to the opposite face. The stone was then turned over and the operation repeated. This produced an implement rhomboidal in cross-section, the faces constituting the width and the edges or short sides the thickness of the blade. When viewed with the point directed upward, the beveling is usually toward the left;

only a rare, sporadic example shows the reverse, with the chipping sloping away to the right. Perhaps this constitutes a record of right- and left-handedness in the group which made and used them. A few specimens in the collection do not correspond to the general pointed type, but have broad, unworked ends. Their sides, however, are beveled in characteristic fashion. The beveled edge is not confined to tools of this type; it occurs, singly, on some of the side scrapers. Perhaps the beveled points should only be considered as broken tips from knife blades. Yet basal portions have not come to light, and it would seem that the implements found represent the complete tool. They would serve well in the capacity of a knife, particularly in the skinning of an animal, where the cutting motion was toward the user. Those with the broad, unchipped ends would not do for such a purpose and must have been employed as a variety of scraper. The triangular examples could also be used as reamers in enlarging holes started with a small punch or borer.

The bevel-edged tools in this collection are not unique for North America, but it is interesting to note that the form occurred in the Folsom horizon. Henry B. Collins, Jr., has examples that he found in Alaska.[31] Kidder obtained a number of knife blades in his work at Pecos which exhibit the feature.[32] There are examples from late Plains sites, and they are fairly numerous in certain districts in Ohio, Alabama, Tennessee, and Georgia.[33] These forms are more definite in their shaping, however, and are presumably of a much later date.

The triangular forms of the bevel-edged tool found at the Lindenmeier site range from 25 to 30 mm in length, 26 to 32 mm in width, and 4 to 6 mm in thickness. The flat-ended forms are from 27 to 40 mm in length, 29 to 33 mm in width, and from 6 to 8 mm in thickness.

GRAVERS

The tools given the designation "gravers" constitute one of the most interesting groups in the whole collection (pl. 13). This is due not so much to the actual nature of the specimens themselves as to their indication that some form of the engraver's art was practiced by the makers of the Folsom points. No objects exhibiting such handiwork were found, but the character of the implements suggests that further work may uncover pieces of bone or other material, similarly resistant to the agents of decay, upon which designs were scratched.

[31] Collins, 1931, 1932.

[32] Kidder, 1932, pp. 30-34.

[33] Fowke, 1896, pp. 160-161, 177-178. Wilson, 1899, pp. 931-934.

The later Indian tribes employed the engraver's art extensively, although it never reached a high degree of excellence north of Mexico, and it is not unreasonable to suppose that it was one of the cultural features in earlier periods. Other peoples in comparable stages of development are known to have responded to the creative urge by drawing with stone on bone, and it is not assuming too much to concede the ability for delineation to such skilled chippers of "flint" as the Lindenmeier group, particularly since there was so abundant a supply of stone and bone ready at hand.

The simplest and most numerous gravers consist of fortuitous flakes which were modified only to the extent of chipping a small, sharp point on one side or end (pl. 13, *a-g*). These short, needlelike points are superficially similar to those commonly classed as drills or borers. They differ, however, in that one face is flat, while the other has beveled edges and a chisellike tip. The usual drill points are chipped on all sides. Furthermore, on several of the present examples small, almost microscopic, flakes have been broken away from the point. The appearance of this feature is such as to suggest that it was caused by a scratching or gouging movement of the implement rather than by a rotary twist such as is used in drilling. On only one of the tools in this group is the point long enough to have functioned as an awl. A hole could be punched through a thin hide with it, but its shape is not adapted to even the slight twisting motion ordinarily accompanying such a procedure. The gravers in this group are from 20 to 44 mm long, 18 to 28 mm wide, and 2.5 to 3 mm thick. The points are consistently from 1.5 to 2 mm long and 1 to 1.5 mm wide at the base.

Some of the gravers are more definitely shaped than the scrap-flake series just described. (See pl. 13, *h-j*.) They were also made from flakes, but the points are broader, more elongated, have a definite bevel on the tip, and exhibit superior workmanship. The chipping is not confined to the actual point but extends along the edges. The finest specimen in this group is *j*, plate 13. The tool was made from a flake, but the entire stone was chipped to obtain the desired shape for the implement. Both faces, the lateral surfaces, and the ends received careful attention from the maker. In addition there is a fine marginal retouch along two edges and around the narrow end. The tip of the latter has a pronounced bevel. The entire object is suggestive of modern tools used in lathe work. Perhaps this particular implement should be classed as a chisel rather than a graver, yet it would have functioned well in the latter capacity. As a matter of fact, there is a certain over-lapping of meaning in the terms "chisel" and "graver,"

and in the present preliminary classification fine distinctions are not essential. The more definitely shaped gravers are from 32 to 38 mm long, 16 to 29 mm wide, and 5 to 9 mm thick. The points are from 9 to 10 mm long.

Several combination tools were found (pl. 13, *k-m*). These incorporate the qualities of the scraper and the graver in a single implement. One typical "snub-nosed" scraper (pl. 13, *k*) has a small sharp-tipped graver point at one end of the convex scraper edge. There is a second graver midway along one lateral edge. With these two points the implement could have functioned as an instrument for drawing parallel lines or for making circles. The point at the end of the tool could have been used for any purpose that the single, simple gravers served. The opposite lateral edge is a good concave side-scraper. With a tool of this type the artisan could perform a number of operations without changing implements. This specimen has a length of 38 mm, breadth of 28 mm, and a thickness of 6.5 mm. The graver points are 2 and 1 mm long and 2 and 1.5 mm broad at the base.

The two specimens *l* and *m*, plate 13, are combination gravers and sidescrapers. The scraper features are concave and convex. One of the artifacts has two graver points, in this case on opposite sides, whereas the other has only one. The latter, however, is one of the most precisely chipped points in the entire collection. These implements are 39 and 42 mm long, 22 and 22.5 mm wide, 3.5 and 4.5 mm thick. The single point on the one is 2.5 mm long and 1.5 mm broad at the base. The points on the other are 1.5 and 2 mm long and 1 mm wide at their bases.

KNIVES

There are a number of specimens which may be classed under the heading of knives. The best examples are carefully chipped blades which exhibit typical Folsom characteristics in their fluted faces and the marginal retouch along the edges. Their ends, however, are rounded, and the sides tend to be parallel rather than bulging or tapering as in the case of the points (pl. 7, *m, n*). The complete specimen is 51 mm long, 23 mm wide, and 4 mm thick. The broken one is 25 mm wide and 3 mm thick.

The channel flakes from typical Folsom points were not always discarded. Several examples show that they were used as knives. Close inspection of the edges reveals minute retouching, which perfected the cutting qualities of the stone and made a serviceable tool from one of the by-products of the process of point manufacture.

There is extreme variation in the length of these objects. This may be attributed to their thinness and liability to breakage. Specimens range from 23 to 46 mm in length, 13 to 17 mm in width, and 1.5 to 2 mm in thickness.

A crude, yet efficient implement was the flakeknife (pl. 14, *a-e*). Tools of this type were made from large, ribbonlike fragments of stone modified only to the extent of chipping along the edges. On some of these implements the chipping is large and irregular. On others it is as minute and precise as could be desired. Both concave and convex edges are present in the series, occuring either singly or in combination on the same implement. Study of such flakes suggests that they were first employed as struck off the nodule, the razor-keen edge of the stone being ideal for cutting purposes. Then as the edge became nicked and dulled through use, it was touched up with the flaking tool until, eventually, the whole edge was chipped. Because of their rough, unfinished nature, implements of this type have received scant notice in American archeology and, if mentioned at all, have frequently been dismissed with the explanation that they were rejects, scrap "flints" tossed aside because they were not good enough to work into finished tools. This certainly was not true of the present group, as the objects obviously are implements. They would readily function for cutting chunks of meat for the stew-pot or even for the skinning of an animal. The length of the specimens in this group varies from 49 mm to 88 mm, the breadth from 15 to 36 mm, and the thickness from 4.5 to 10 mm.

A second group of flakeknives consists of a border-line series of larger implements which could serve either as knives or scrapers and which could be included in one or the other category with equal justification (pl. 14, *f-n*). The main reason for listing them as knives is that most of them have a peculiar twist to the flake which makes them more adaptable for cutting purposes than for scraping. These implements, as mentioned also in the discussion of other types, no doubt served a variety of purposes, and a hard and fast classification of the form is out of the question. The group ranges in length from 53 to 111 mm, in breadth from 38 to 74 mm, and in thickness from 8 to 10 mm.

BLADES AND CHOPPERS

Included in the collection are leaf-shaped blades and several large points which appear to be ends broken from such blades (pl. 15, *a-h, k*). The blades are reminiscent of the so-called blanks which represent the intermediate stage between the original nodule and the

completed implements. Ordinarily, among the later Indians, the specialization of the blanks was not undertaken at the quarry where they were roughed out. Instead they were taken home and then perfected as time permitted. At the Lindenmeier site, however, the process was probably carried through from start to finish on the spot because the material was right at hand. The present specimens are not true blanks despite their close resemblance to those forms. They are actual implements. This is shown by the careful secondary chipping along the edges. Such blades may be considered as combination knives and scrapers. Whether the broken ends should simply be regarded as such or whether they should be classed as scrapers is a difficult question to answer. Primarily they are portions from larger blades, but they also served as implements in their present state. The smooth-fractured surfaces on the ends of several examples have minute facets, the result of chipping along their edges. In some cases this appears to be the result of use. On others the removal of the tiny flakes was unquestionably intentional. Points of this type, although only a portion of the original tool, would be serviceable as knives or scrapers. The ends are from 32.5 to 50 mm long, 39 to 48 mm wide at the base, and 7.5 to 9 mm thick. The blades measure 52 to 88 mm in length, 28 to 41 mm in width, and 7.5 to 10 mm in thickness.

The class of implements tentatively called choppers might well be considered variations of tools generally known as hand axes and rough celts (pl. 15, *l*, *n*). Because they do not answer in many respects to the usual definitions of such tools and since they obviously were for the same purpose, despite their difference in form, it is thought less confusing to group them together under the designation of choppers. Such tools would have been efficient in splitting and hacking bones. That some such implement was employed is indicated by the bone fragments. One of the examples pictured (pl. 15, *l*) was made from a chalcedony nodule and is one of the few true "core" specimens found at the site. It must have been made definitely for this purpose, as the flakes removed in shaping it were not large enough to have served in the manufacture of other tools. Although the main chipping is large, there is a fine retouch on portions of the edges. The broad end of the tool is well adapted for grasping, and the smooth, flat base would protect the palm of the hand from injury. This implement is 86 mm long, 61 mm broad, and 15 mm thick. The second specimen (pl. 15, *m*) is a pseudo-core; it is the core of a large flake, not that of a complete nodule. In its general shape it strongly suggests the

adze or celt of the later Indians. The workmanship is cruder, however and although it may be an example of the prototype of such tools, it will be considered here as a chopper. Little effort was expended on this implement. The chipping is confined to the one chisel-like end. The base is rough, some of the edges being sharp enough to cut the palm of the hand holding it. It would need to be wrapped in a piece of buckskin or a similar substance to prevent slipping and for the comfort of the user. The stone is 74 mm long, 40 mm broad, and 21 mm thick. There are no marks on either of these specimens to indicate that they might have been hafted in some kind of handle.

MISCELLANEOUS OBJECTS

The pieces of sandstone in the collection cannot be assigned to any definite class of implements, yet all show signs of use. There is no material of this nature in the immediate neighborhood, and the stones must have been carried in for a particular purpose. Two of them, although irregular in form, have a slight groove along one side. The surface of the stone in the grooves is rubbed as though the objects might have served as shaft polishers (pl. 16, *a, b*). They are not typical of the implements generally called shaft polishers, however. One stone is flat, roughly oval in outline, and has a shallow concavity in one face (pl. 16, *c*). Traces of red pigment still adhering to the stone suggests that it functioned as a pigment bowl. It does not seem likely that this was a mortar for grinding paint, as it shows no effects of a pestle. It was merely a palette. One irregularly shaped stone has a smooth surface on one side, which indicates that it served as a rubbing stone (pl. 16, *e*). Another was shaped, but there is nothing to suggest what its purpose may have been (pl. 16, *d*). One example is flat with one curved edge. The specimen obviously is not complete, and it may be the remaining portion of a lid or cover for some container. The curved outer edge has a series of facets where flakes were knocked off in the shaping process (pl. 16, *f*). The material is soft and could easily have been ground into the desired form but, in accord with the prevailing technique of the horizon, the flaking process was employed.

A number of pieces of hematite were recovered from the deposits. The surfaces of all of them are smooth and striated from rubbing. This is a good indication that they supplied pigment material, a factor which correlates with the presence of the sandstone object suggestive of a pigment bowl. Hematite in its various forms was extensively used by the later Indians for making implements, ornaments, and

small objects whose purpose is unknown. It also served as a source for paint, the compact red, earthy varieties known as red chalk and the pulverulent red ocher being especially popular for this purpose. Powdered hematite was mixed with grease or saliva and then applied to the object to be painted. It was used for facial decoration, for coloring skins and hides, for painting spears, arrows, shields, skin tents, and other objects which the Indian desired to embellish. The finding of the material at the Lindenmeier site is good evidence that the makers of the Folsom points were also users of red paint. None of the fragments indicate that they were shaped to serve as ornaments, nor are they of the problematical object type.

Several nodules with battered ends were found, and there is one flat stone of granite, roughly circular in outline but with one flattened edge, which is broken away along one side as though from blows. These objects no doubt served as hammers. They could be employed in knocking flakes off large nodules, for cracking bones, and in other capacities where a striking implement would be required. The flat granite specimen has one convex, smooth side, which suggests that it also may have served as a rubbing stone (pl. 16, *g*).

There are a number of bones in the collection which, although they are only chance scraps, indicate that they could have served as tools. Each of these objects has a tapering, blunt-pointed end which shows some signs of wear. They may have functioned as punches or awls, but because they are not definitely prepared implements and do not exhibit pronounced signs of usage, they will be regarded only as fortuitous tools at this time. When more evidence is available, it may develop that split bones with such ends actually should be classed as a type of implement. For the present, definite conclusions will be held in abeyance.

IDENTIFICATION OF BONES

Owing to the scrappy nature of most of the bone material recovered, it has not been possible to identify all of the animals represented. Some of the fragments are from small mammals, but most of them are bison. Part of the latter material, portions of jaws and a good series of teeth, was referred to Director J. D. Figgins, of the Colorado Museum of Natural History, who has made a specialty of the study of bison remains. He reports that the bison found at the original Folsom site, *Stelabison occidentalis taylori* and *Bison oliverhayi*,[34] are

[34] Figgins, 1933 b.

represented in the material from the Lindenmeier site. In this connection he wrote:

> There was no trouble identifying the material not too badly damaged. We have the types of all the bison we have described, in addition to many jaws and separate teeth, so that it was merely a matter of comparison and measurement. You may be assured of the accuracy of the identifications, as your specimens check, in every respect, with our Folsom, New Mexico, types. I entertain no slightest doubt that your material is typical of the two Folsom races.[36]

The occurrence of the same species of bison at the two sites is of particular interest and serves to tie them to the same general horizon. The full significance of the material, however, is still to be determined. The bison with which the Folsom artifacts are associated were larger than the modern species and had more massive, less sharply curved horns.

Other bones, identified by Dr. Remington Kellogg, assistant curator, division of mammals, United States National Museum, are from the fox (*Vulpero velox*), the wolf (*Canis nubiltus*), and the rabbit (*Lepus townsendii companius*). Unfortunately, none of these throws any light on the question of the age of the site, as it is not possible to differentiate between the Pleistocene and present-day forms. It is interesting, though, to have this addition to the fauna of the Folsom horizon.

SUMMARY

At the Lindenmeier site in northern Colorado is the first occupation level yet found which can be definitely correlated with the makers of the now well-known Folsom points. Distinct traces of a former campsite and workshop are present at this location. Midden deposits have yielded a series of implements actually associated in situ with typical Folsom points. Similar tools have been found at various surface sites, but this is the first evidence to demonstrate that they belonged to the Folsom complex. In addition to the assortment of artifacts, there are flakes, spalls, and nodules, indicating that the implements were made on the spot. Furthermore, this chipper's debris gives good clues to some of the methods used in shaping the tools. The artifacts in the collection show that the lithic component in the local culture pattern was primarily a flake industry, only a few implements of the core type being found. Cut, broken, and split animal bones from the deposits have been identified as being from bison, fox, wolf, and rabbit. The bison remains indicate that those animals belonged to the same extinct species as those found at the original Folsom quarry. This is a significant link between the two sites.

---

[36] Letter from Mr. Figgins to the writer, Feb. 28, 1935.

BIBLIOGRAPHY

Anonymous

1932. Arrowheads found with New Mexican fossils. Science, n. s., vol. 76, Nov. 25, Supplement, pp. 12-13.

1933. Early Man in America. Science, n. s., vol. 78, Aug. 18, Supplement, pp. 7-8.

1934 a. Bones and dart points date American 12,000 years old. Sci. News Lett., vol. 26, p. 147, Sept. 8.

1934 b. New knowledge about ancient Americans. Lit. Dig., p. 18, Oct. 17.

Antevs, Ernst

1935. The spread of Aboriginal Man to North America. Geogr. Rev., vol. 25, no. 2, pp. 302-309, April.

Barbour, E. H., and Schultz, C. B.

1932. The Scottsbluff bison quarry and its artifacts. Nebraska State Mus., Bull. 34, vol. 1, December.

Beauchamp, W. M.

1897. Aboriginal chipped stone implements of New York. Bull. New York State Mus., vol. 4, no. 16, October.

Bell, E. H., and Van Royen, W.

1934. An evaluation of recent Nebraska finds sometimes attributed to the Pleistocene. Wisconsin Archeol., n. s., vol. 13, no. 3, pp. 49-70, April.

Brown, C. S.

1926. Archeology of Mississippi; Mississippi Geological Survey. University of Mississippi.

Bryan, W. A.

1929. The recent bone-cavern find at Bishop's Cap, New Mexico. Science, n. s., vol. 70, pp. 39-41, July 12.

Collins, H. B., Jr.

1931. Ancient culture of St. Lawrence Island, Alaska. Explorations and Field-Work of the Smithsonian Institution in 1930 (Publ. 3111), pp. 135-144.

1932. Prehistoric Eskimo culture on St. Lawrence Island. Geogr. Rev., vol. 22, no. 1, pp. 107-119, January.

Cook, H. J.

1927. New geological and paleontological evidence bearing on the antiquity of Mankind. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, no. 3, pp. 240-247, May.

1928. Glacial age Man in New Mexico. Sci. Amer., vol. 139, pp. 38-40, July.

1931. More evidence of the "Folsom-Culture" race. Sci. Amer., vol. 144, pp. 102-103, February.

Figgins, J. D.

1927. The antiquity of Man in America. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, no. 3, pp. 229-239, May.

1931. An additional discovery of the association of a "Folsom" artifact and fossil mammal remains. Proc. Colorado Mus. Nat. Hist., vol. 10, no. 4, Sept. 26.

1933 a. A further contribution to the antiquity of Man in America. Proc. Colorado Mus. Nat. Hist., vol. 12, no. 2, August 1.

1933 b. The bison of the western area of the Mississippi Basin. Proc. Colorado Mus. Nat. Hist., vol. 12, no. 4, Dec. 5.

1934. Folsom and Yuma artifacts. Proc. Colorado Mus. Nat. Hist., vol. 13, no. 2, Dec. 29.

Fowke, Gerard.

1896. Stone art. 13th Ann. Rep., Bur. Amer. Ethnol., pp. 47-178.

Harrington, M. R.

1933. Gypsum Cave, Nevada. Southwest Mus. Pap., no. 8. Los Angeles.

Hay, O. P., and Cook, H. J.

1930. Fossil vertebrates collected near or in association with human artifacts at localities near Colorado, Texas; Frederick, Oklahoma; and Folsom, New Mexico. Proc. Colorado Mus. Nat. Hist., vol. 9, no. 2, Oct. 20.

Holmes, W. H.

1919. Handbook of aboriginal American antiquities, pt. 1, Introductory, the lithic industries. Bull. 60, Bur. Amer. Ethnol.

Howard, E. B.

1932. Caves along the slopes of the Guadalupe Mountains. Bull. Texas Archeol. and Paleont. Soc., no. 4, pp. 7-19.

1933. Association of artifacts with mammoth and bison in eastern New Mexico. Science, n. s., vol. 78, p. 524, Dec. 8.

1934. Grooved spearpoints. The Pennsylvania Archeologist, Bull. Soc. Pennsylvania Archeol., vol. 3, no. 6, January.

Jenks, A. E.

1934. The discovery of an ancient Minnesota maker of Yuma and Folsom flints. Science, n. s., vol. 80, p. 205, Aug. 31.

1935. Recent discoveries in Minnesota prehistory. Minnesota History, a Quarterly Magazine, vol. 16, no. 1, pp. 1-21, March.

Kidder, A. V.

1932. The artifacts of Pecos. Papers of the Southwestern Expedition, No. 6. Robert S. Peabody Foundation for Archeology, Phillips Academy, Andover. Yale Press, New Haven.

Renaud, E. B.

1928. L'antiquité de l'homme dans L'Amerique du Nord. L'Anthropologie, vol. 38, pp. 23-49.

1931 a. Prehistoric flaked points from Colorado and neighboring districts. Proc. Colorado Mus. Nat. Hist., vol. 10, no. 2, March 31.

1931 b. Archeological survey of eastern Colorado. Univ. Denver Dep. Anthrop. June.

1932 a. Archeological survey of eastern Colorado. (Second Report) Univ. Denver Dep. Anthrop. March.

1932 b. Yuma and Folsom artifacts (new material). Proc. Colorado Mus. Nat. Hist., vol. 11, no. 2, November 19.

1933. Archeological survey of eastern Colorado. (Third Report) Season 1932. Univ. Denver Dep. Anthrop. March. (Chapter 5, pp. 39-40, for Yuma and Folsom points.)

1934 a. Archeological survey of western Nebraska. Summer 1933. Univ. Denver Dep. Anthrop. May. (Chapter 5, pp. 38-40, for Yuma and Folsom points.)

1934 b. The first thousand Yuma-Folsom artifacts. Univ. Denver Dep. Anthrop. October.

SCHULTZ, C. B.
1932. Association of artifacts and extinct mammals in Nebraska. Bull. 33, Nebraska State Mus., vol. 1, November.

SPENCER, LILIAN W.
1935. The first Americans, Folsom Man—? New Mexico, the State Magazine of National Interest, vol. 13, no. 1, pp. 23-24, 40-42, January. Santa Fe.

THONE, FRANK.
1929. Did earliest American hunt sloth? Science News Letter, vol. 16, no. 445, pp. 237-239, October.

THRUSTON, G. P.
1890. The antiquities of Tennessee and the adjacent states and the state of aboriginal society in the scale of civilization represented by them. A series of historical and ethnological studies. (1st ed.) Cincinnati.

WILSON, THOMAS.
1899. Arrowpoints, spearheads, and knives of prehistoric times. Rep. U. S. Nat. Mus. 1897, pp. 811-988.

1. RAVINE IN WHICH MAIN DEPOSIT WAS FOUND

2. DEEP PIT AT THE BEGINNING OF INVESTIGATIONS

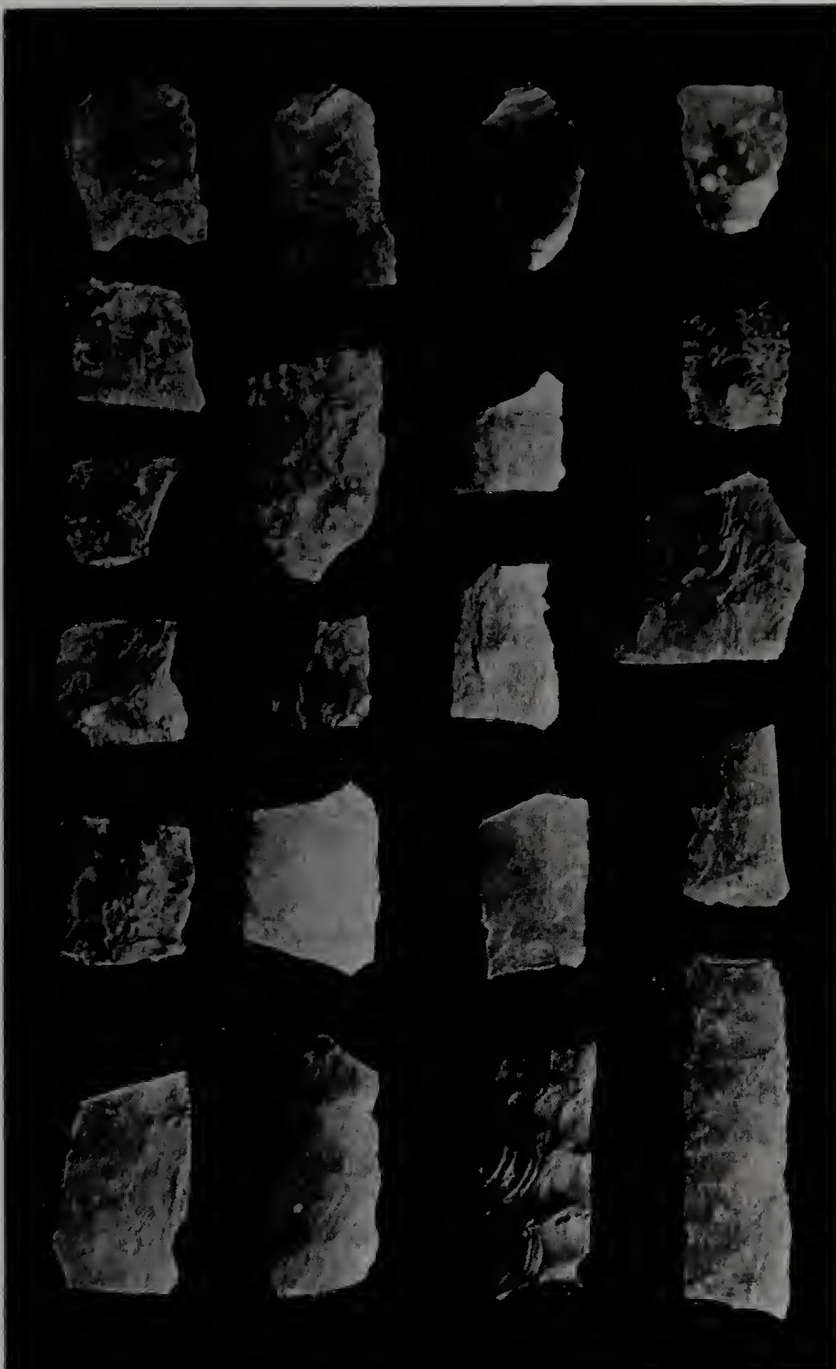
Man is standing on level where material was obtained.

1. SOIL LAYER IN WHICH SPECIMENS OCCUR

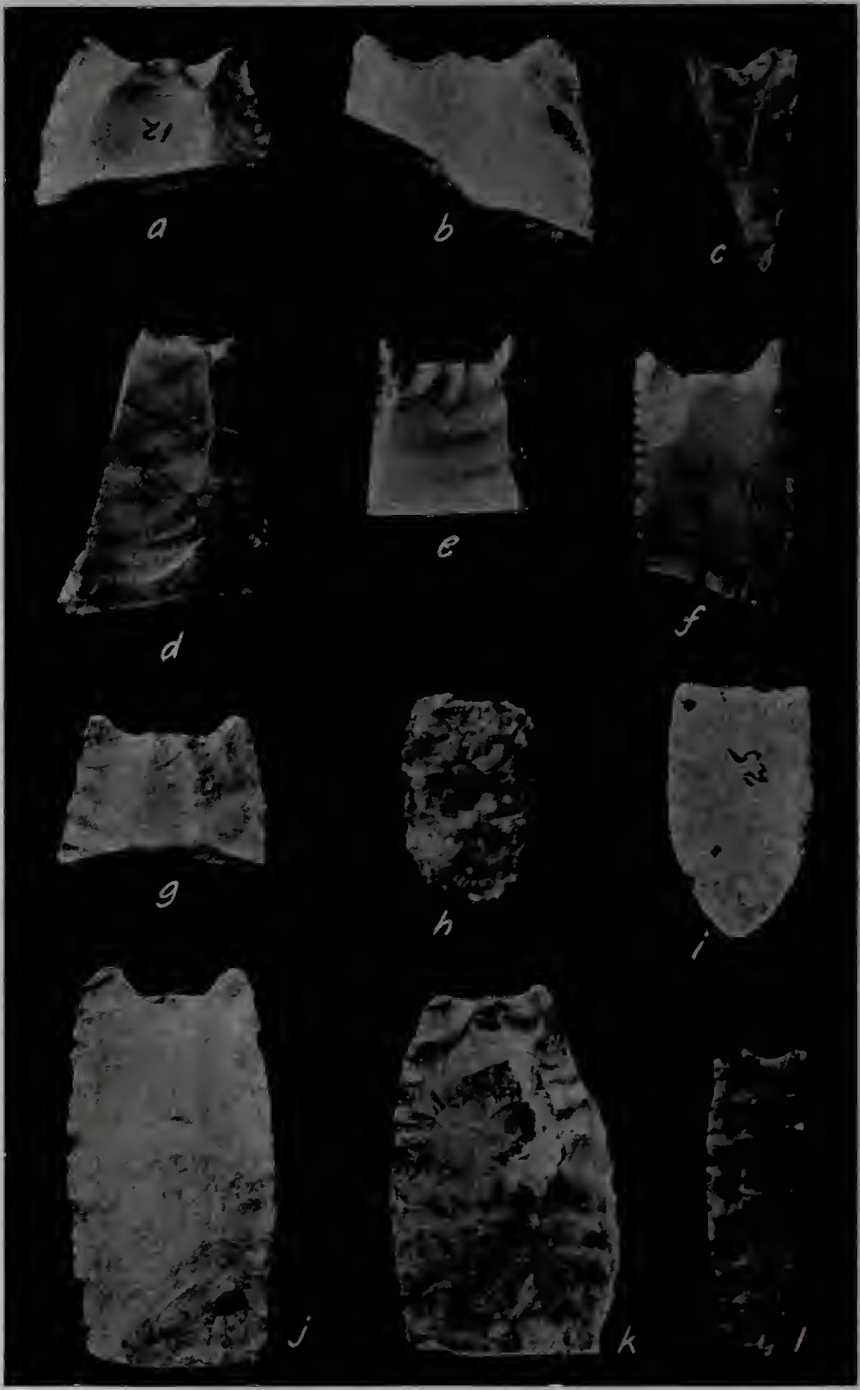
Bones are resting on top of Oligocene bed. A. L. Coffin at right of picture.

2. BONES AND "FLINT" IN SITU IN DEPOSIT

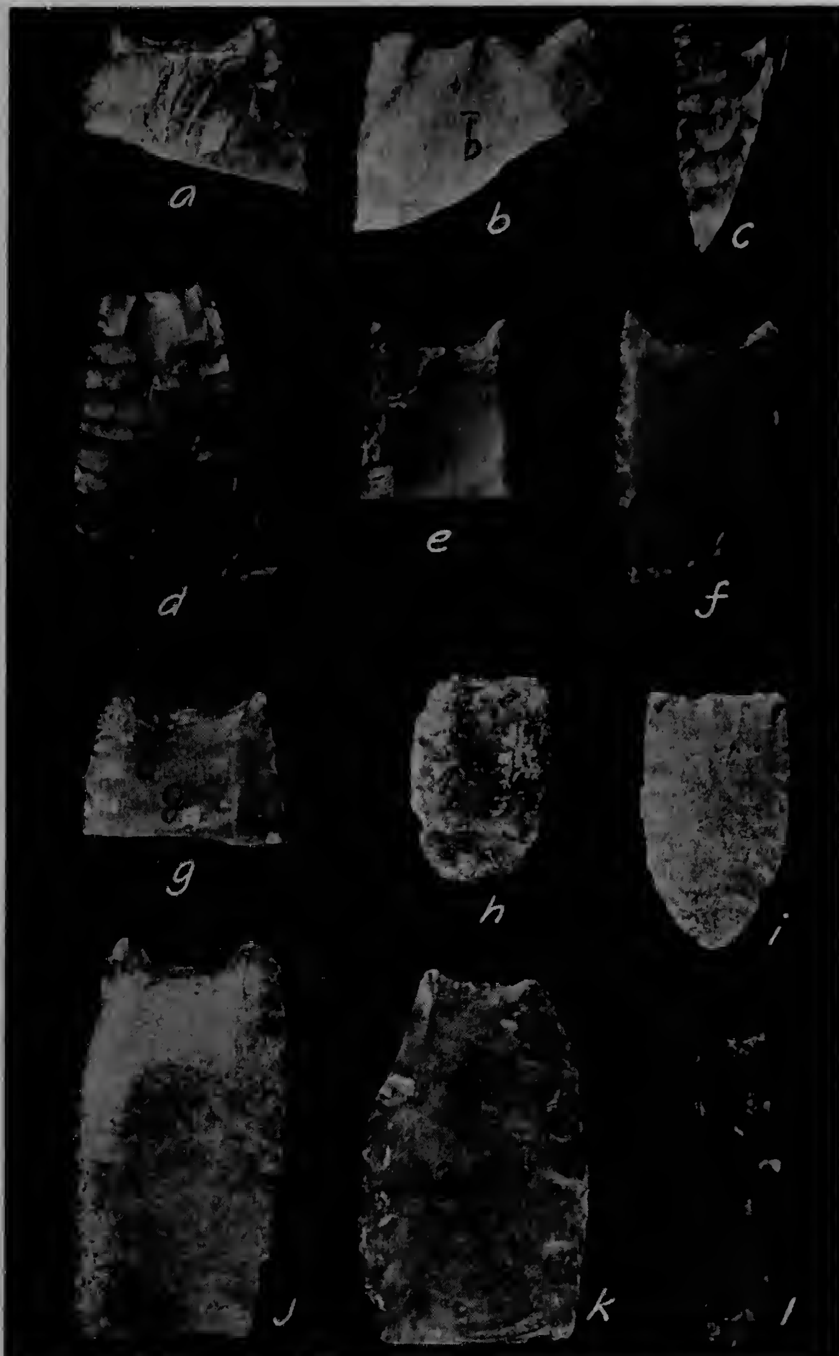
Arrow points to implement.



Channel Flakes from Folsom Points
Actual size.



PORTIONS OF FOLSOM POINTS
Actual size.



REVERSE OF POINTS SHOWN IN PLATE 5

Actual size.

FRAGMENTS FROM FOLSOM POINTS AND KNIVES
Actual size.

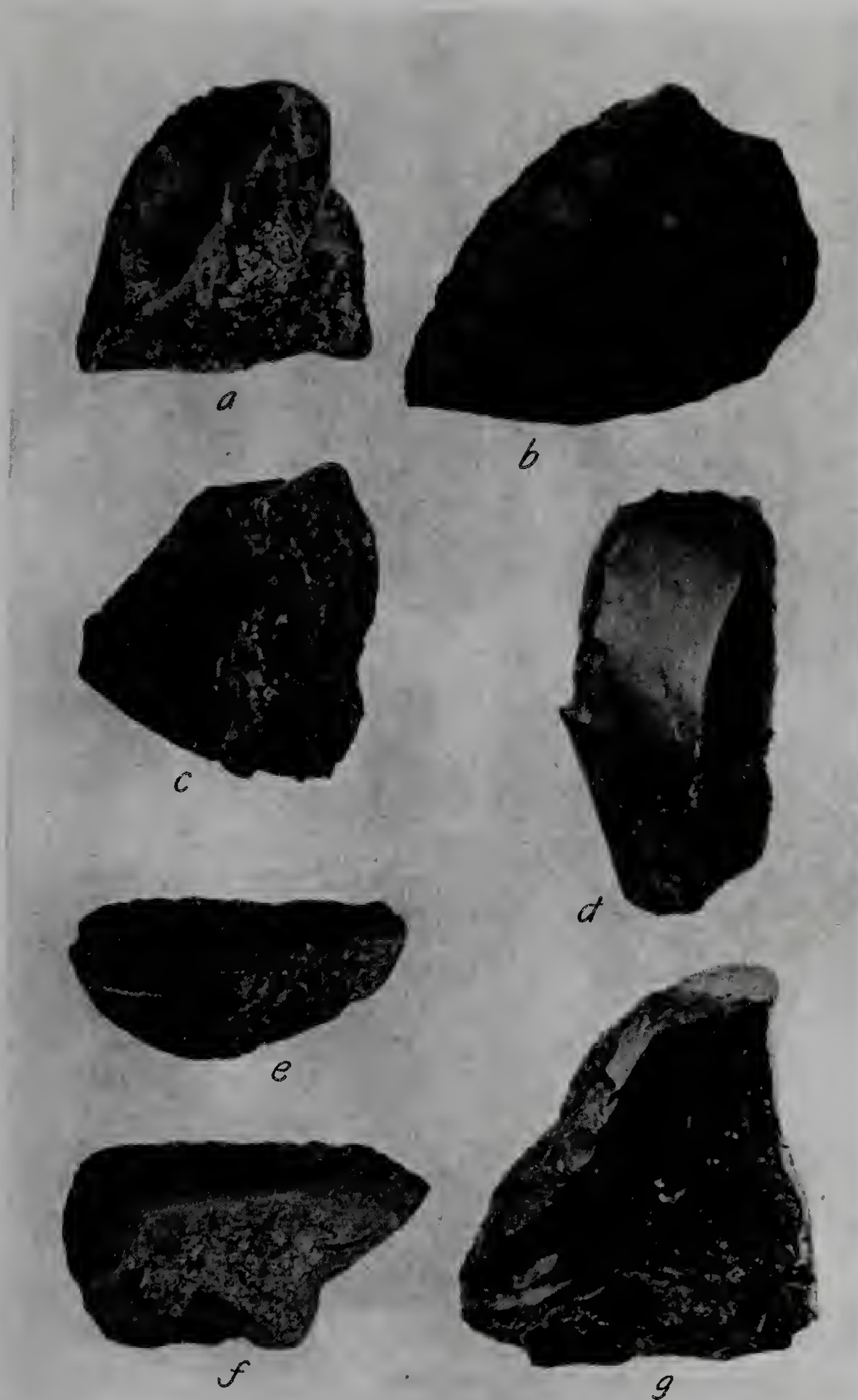
Reverse of Points and Knives Shown in Plate 7

Actual size.

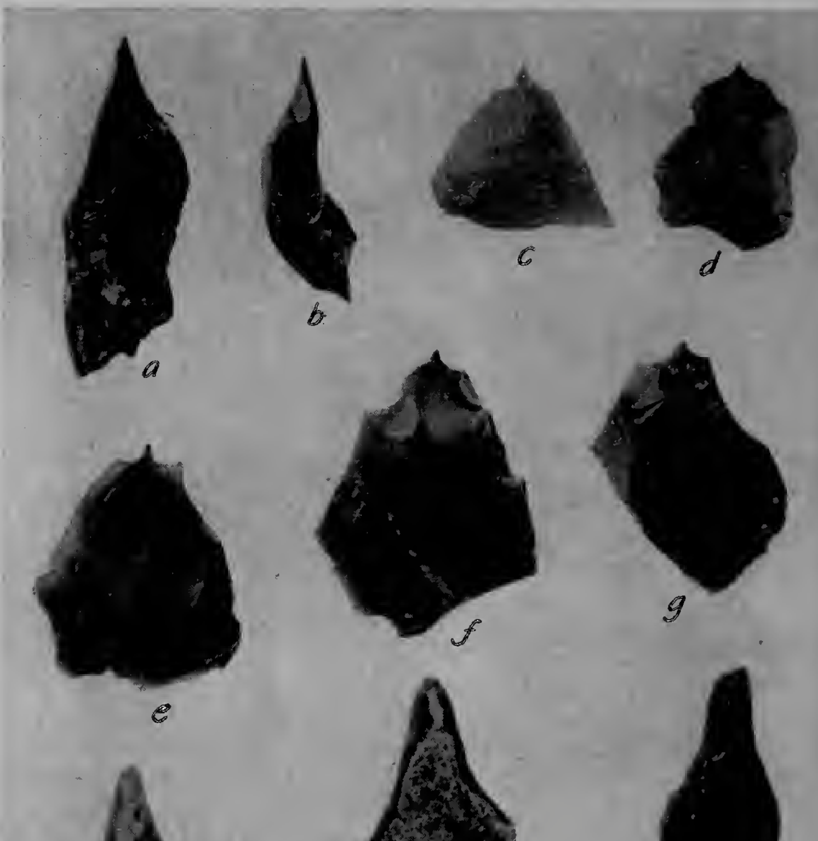
"SNUB-NOSED" SCRAPERS
Actual size.

END, SIDE, AND BACK VIEWS OF "SNUB-NOSED" SCRAPERS
Actual size.

SIDE SCRAPERS
Actual size.



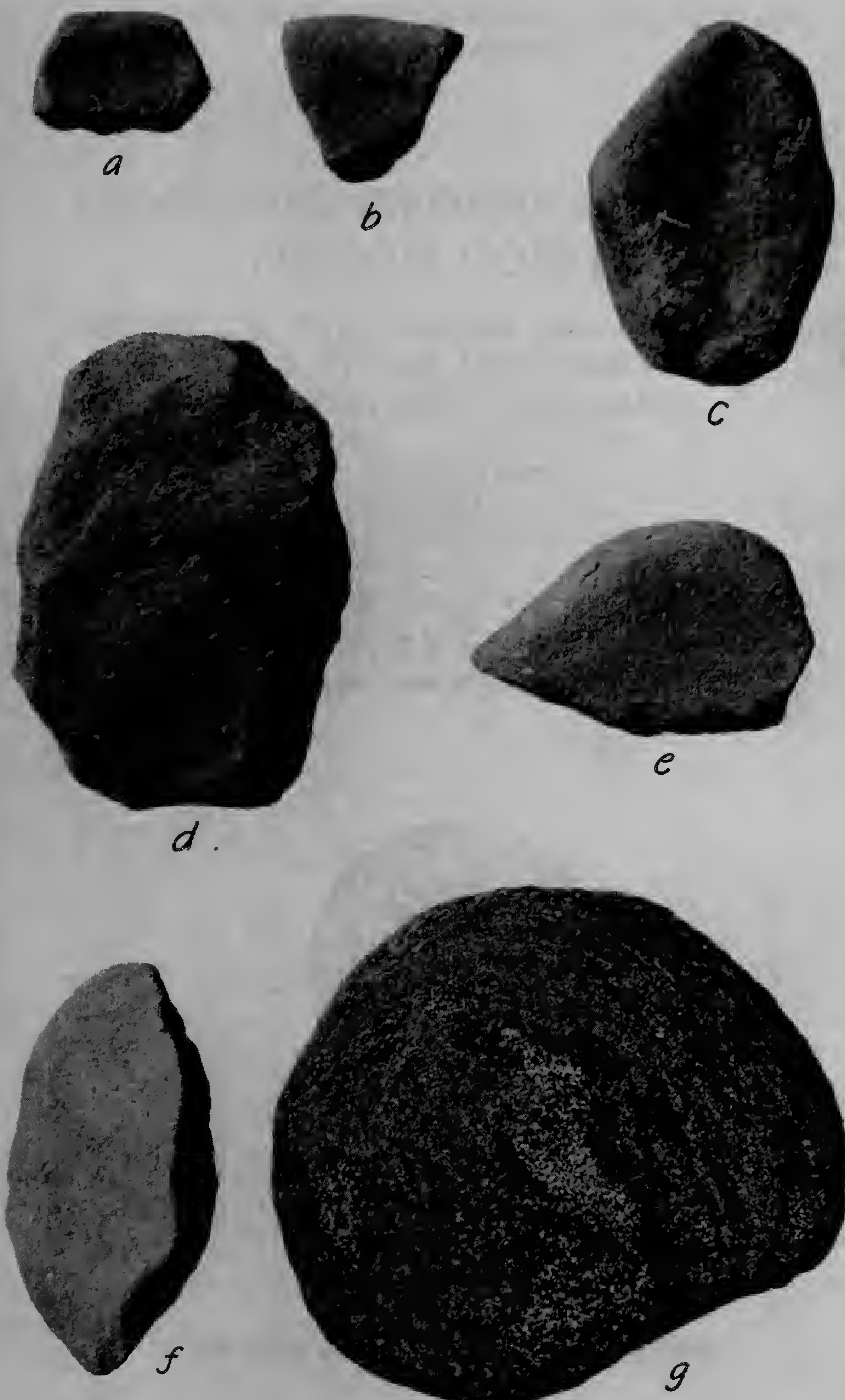
ROUGH-FLAKE SCRAPERS
Actual size.



GRAVERS
Actual size.

ROUGH-FLAKE KNIVES
One-half size.

BLADES, POINTS, TURTLEBACKS, AND CHOPPERS
One-half size.



SANDSTONE OBJECTS AND GRANITE RUBBING STONE

One-half size.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 95, NUMBER 10

ADDITIONAL INFORMATION ON THE FOLSOM COMPLEX

REPORT ON THE SECOND SEASON'S INVESTIGATIONS AT THE LINDENMEIER SITE IN NORTHERN COLORADO

(With 12 Plates)

BY
FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

(Publication 3390)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JUNE 20, 1936

CONTENTS

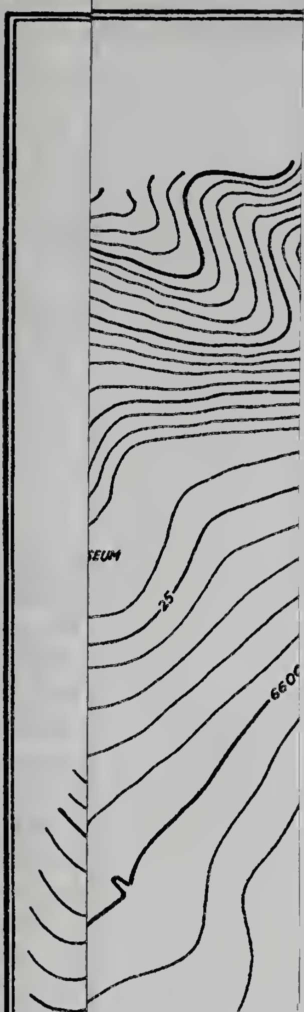
ILLUSTRATIONS

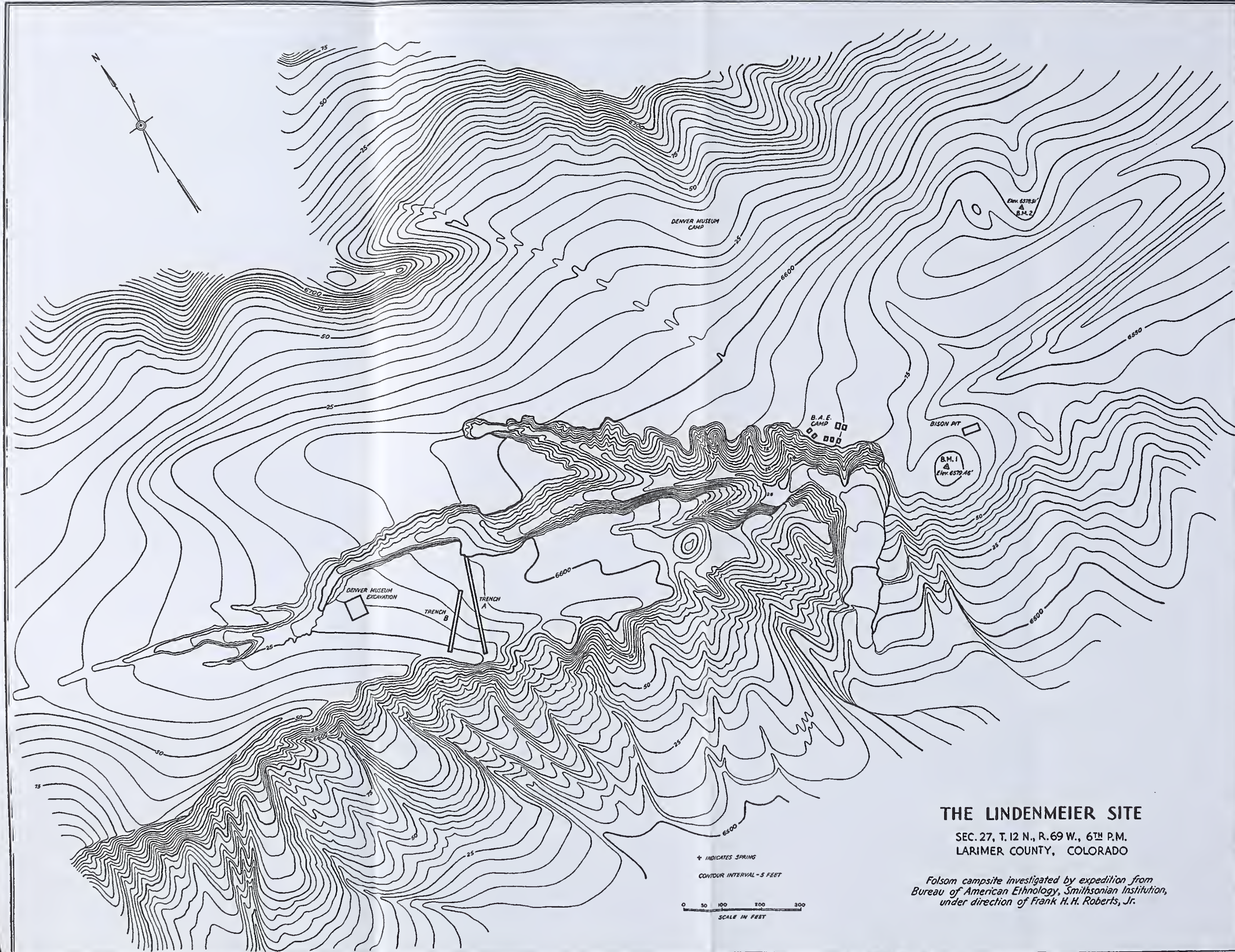
PLATES

TEXT FIGURES

MAP

SMITHSON





THE LINDENMEIER SITE

SEC. 27, T. 12 N., R. 69 W., 6TH P.M.
LARIMER COUNTY, COLORADO

Folsom campsite investigated by expedition from Bureau of American Ethnology, Smithsonian Institution, under direction of Frank H. H. Roberts, Jr.

ADDITIONAL INFORMATION ON THE FOLSOM COMPLEX

Report on the Second Season's Investigations at the Lindenmeier Site in Northern Colorado

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

(With 12 Plates)

INTRODUCTION

During the summer of 1935 further investigations were conducted at the Lindenmeier site in northern Colorado. It was at this location that the first definite complex of stone implements attributable to Folsom man was found in situ in the autumn of 1934.[1] From the first of June until early September the writer and a group of associates carried on a series of excavations in an effort to obtain more information on this little-known phase of American archeology. The results were gratifying in some respects but in others fell short of expectations. The digging yielded 750 artifacts, large quantities of chipper's debris—innumerable fragments of stone forming a byproduct of the tool-making industry—and several deposits of bones from animals whose flesh or skins had been used by the one-time dwellers at the site. No human skeletal material was found. This was disappointing, inasmuch as all interested in the subject are anxious to know what the people are like who made the implements. Fragments of charcoal and scattered ashes were plentiful, but no indications of a shelter or habitation were observed. The presence of hammerstones accompanied by chips and flakes was noted at a number of places. These suggested that one or more individuals had been seated there while shaping tools out of rough stone nodules. Pieces of several projectile points, as well as other implements, that had been broken in the making were obtained from one such spot. By fitting the fragments together and restoring the flakes it is possible to gain good evidence concerning the technique used in manufacturing the tools.

Dr. Kirk Bryan, of the division of geology, Harvard University, assisted by Franklin McCann and John T. Hack, spent the month of

[1] Roberts, 1935.

July in studying the geology of the district. As a part of their investigations they prepared a map of a portion of the terrain lying to the east of the archeological site. To facilitate their work, a level was run from a United States Geological Survey bench-mark (located on the line between sec. 19, T. 12 N., R. 68 W., and sec. 24, T. 12 N., R. 69 W., sixth principal meridian) and an accurate bench-mark based on mean sea level datum established at the site. E. G. Cassedy, illustrator for the Bureau of American Ethnology, joined the party in August and made a survey of the site proper, and some of the outlying area not mapped by Bryan. Mr. Cassedy has combined his and Bryan's surveys in a map showing the general topographical features of the site and adjacent region.

The announcement of the finds made at the Lindenmeier site in the autumn of 1934 attracted wide-spread attention and aroused a lively interest in the subject. As a result there were many visitors while work was under way. The numerous groups included anthropologists, paleontologists, geologists, geographers, and various scientists whose fields of research are not closely related to the present investigations. Among the anthropologists attracted to the site during the summer of 1935 were: A. V. Kidder and E. H. Morris, of the Carnegie Institution of Washington; E. W. Haury and E. B. Sayles, of Gila Pueblo, Globe, Ariz.; Donald Scott, of the Peabody Museum, Cambridge, Mass.; L. L. Leh, of the Department of Anthropology, University of Colorado; R. L. Zingg, of the University of Colorado Summer School, and his class in anthropology. Dr. E. B. Renaud, of the University of Denver, visited the site a number of times prior to 1935, and W. D. Strong, of the Bureau of American Ethnology, spent 2 days there while the writer was at work in the autumn of 1934. Geologists, paleontologists, and geographers present during the summer were: Paul MacClintock, Princeton University; Frederic B. Loomis, Amherst College; Wm. Van Royen and A. L. Lugn, University of Nebraska; C. Bertrand Schultz, of the Nebraska State Museum.

Members of the party engaged in the actual archeological work during the 1935 season were: W. C. Beatty, Jr., Denver, Colo.; C. T. R. Bohannon, Washington, D. C.; A. L. Coffin, Fort Collins, Colo.; L. C. Eiseley, Lincoln, Nebr.; H. L. Mason, Silver Spring, Md.; Carl F. Miller, Tucson, Ariz.; Roger Mixter, Boston, Mass.; Wayne Powars, Greeley, Colo.; and George L. McLellan, Lodi, Calif.

The Lindenmeier site, as described in the preliminary paper issued in the spring of 1935,[2] is located on an old valley bottom, which, owing

[2] Roberts, 1935.

to the eroding away of the ridges which once bordered it along one side, now constitutes a terrace above an intermittent tributary to a series of streams which ultimately join the South Platte River. The work in 1934 was mainly confined to a deep deposit of midden material exposed in the side of a ravine that cuts across the terrace in the zone of former occupation, but traces of the cultural stratum were also noted at several points along the edge of the terrace. The plan of procedure in 1935 called for the digging of two large trenches between the edge of the terrace and the bank of the ravine (pl. 1, fig. 1). The trenches were started several hundred feet apart at places where bones and stone chips had been found the previous autumn but were directed so that they would converge at the pit where most of the specimens were obtained. This method of digging was adopted for the purpose of exposing a complete cross-section of the fill overlying the old valley bottom and of determining, if possible, where the artifacts found in the deep deposit had originated.

The expedition did some work near the location of the original Coffin finds. The preliminary report on investigations at the site discussed its discovery by Judge C. C. Coffin and his son A. L. Coffin, and the subsequent reporting of its existence to the Smithsonian Institution by Maj. Roy G. Coffin, professor of geology at Colorado State College.[2] The paper also pointed out that the material described in it came from a place a quarter of a mile to the west of that where the first Coffin finds were made. In discussing the latter the writer mentioned the fact that most of the Coffin artifacts had been picked up from the surface, which is the top of a hard, compact, tufaceous layer, an Oligocene deposit, which underlies the entire site. The artifacts had undoubtedly been in top-level material that had been eroded away by wind and water. Because of their weight the implements remained until picked up. Portions of the sand, gravel, and nodule layer which had overlain the compact deposit remained in some places, and the Coffins had found a few objects on the contact line between the two. After an inspection of the location the writer was dubious about the possibilities of getting more information than that already obtained by Judge and Major Coffin but had discussed a tentative plan of procedure with A. L. Coffin. When the deeply buried deposit was discovered in the ravine bank, indications were that it was a more likely place for obtaining specimens from undisturbed layers, and activities were concentrated at that point.

During the winter and early spring following the writer's first excavations, the Coffins visited the site a number of times, and in

[2] Roberts, 1935, pp. 1-3.

scratching around the remaining "islands" of top-layer earth A. L. Coffin and Major Coffin uncovered some bones at the original location. On the strength of this evidence, trenches were dug through a portion of the area where erosive action had not completely uncovered the basic stratum. This was a fortunate procedure because, contrary to the impression of the preceding autumn, there was evidence still in situ. A bone pile comprising the remains of several individual bison was located there. Some of the skeletons were partially articulated and, in common with a majority of the separate bones, were in a good state of preservation. Although a number of the bones had been cut and split, the material as a whole was much more satisfactory from the standpoint of the paleontologist than that obtained in the earlier work. It made less debatable the identification of the species of bison present at the site and corroborated the conclusion reached the previous year from very scrappy evidence.

Besides animal bones, a number of invertebrates were obtained at the site. Identification of the mollusks contributes further to the knowledge of general conditions at the time of occupation. Fragments of charcoal were saved in the hope that the wood could be identified and contribute still more evidence on the physiographic environment. This material is being studied by Dr. Ralph W. Chaney, of the University of California, but no report on it has been received. Samples of the soil in which the remains were found were tested for possible fossil pollens in a further effort to broaden the picture. This work was done by Margaret Kaeiser, of the University of Oklahoma, under the direction of Dr. Paul B. Sears, head of the department of botany at that institution. Unfortunately, there was no evidence of pollen in the dirt. Dr. Paul S. Conger, custodian of diatoms, United States National Museum, examined earth samples for fossil diatoms, microscopic unicellular algae that inhabit fresh and salt water, but found none. He noted fragments of sponge spicules, although they were too disintegrated for identification.

In addition to the work done by the Smithsonian Institution's field party, investigations were conducted at the Lindenmeier site by the Colorado Museum of Natural History, Denver. Their excavations extended from June 14 to September 1. Jack Cotter, Harley Goettsche, and Robert J. Lanberg comprised the Denver expedition. J. D. Figgins, at that time director of the Denver Museum and now with the Bernheim Foundation near Louisville, Ky., visited the site a number of times while his men were at work there. Mr. Figgins and Mr. Cotter made available to the present writer, for study, all the material

obtained from their excavations, and Mr. Cotter also furnished a copy of the manuscript that he submitted as a report on the work.

The Denver Museum party dug a series of 15 test pits. These were spaced at intervals extending from the area of the original Coffin finds to some distance beyond the main Smithsonian trenches. The pits gave a good sampling of the character of the deposits across the portion of the site lying between the terrace edge and the ravine bank on a line approximately at right angles to the trenches. One of the test holes west of the large trenches penetrated the artifact-bearing stratum at what appeared to be a likely spot. With this as a starting point an area 30 feet by 30 feet was laid off and completely excavated. This large pit (map 1) yielded most of the specimens obtained by the Denver group.

THE MAIN TRENCHES

As previously stated, the major part of the 1935 work consisted in driving two large trenches from the edge of the terrace toward the deep pit where the 1934 activities were centered. The trenches were dug in 10-foot sections. Their bottoms followed the top of the light-colored substratum just below the old soil level which was the surface of the ground at the time when the site was inhabited by the makers of the tools found there. Detailed drawings were made of the faces and side walls in each section, and these give a minute record of events involved in the growth of the valley fill. All of the material obtained from each section was so designated, and in addition the positions of specimens in the section were carefully noted. Only one trench was carried through to completion (pl. 1, fig. 2). The other was stopped when it became apparent that the evidence from it would largely duplicate that from the first. The completed trench was 270 feet (82.296 m) long, 10 feet (3.048 m) wide, and sloped from a depth of 3 feet (.914 m) at the edge of the terrace to 17 feet (5.182 m) in the bank of the ravine. When the work had been completed, the section drawings of the sides of the trenches were combined into one long diagram for each wall (fig. 1). A number of interesting factors are brought out by these diagrams.

The numbers extending across the top of the drawing (fig. 1) indicate the pegs which marked off the courses of the trenches. They were set every 10 feet (3.048 m). References to specific sections in the ensuing discussion will be by number. For example, section 1 consists of that portion lying between pegs 1 and 2, section 2 between 2 and 3, and so on. Neither trench had a complete zero section. As there had already been some digging at the terrace edge, when the presence of

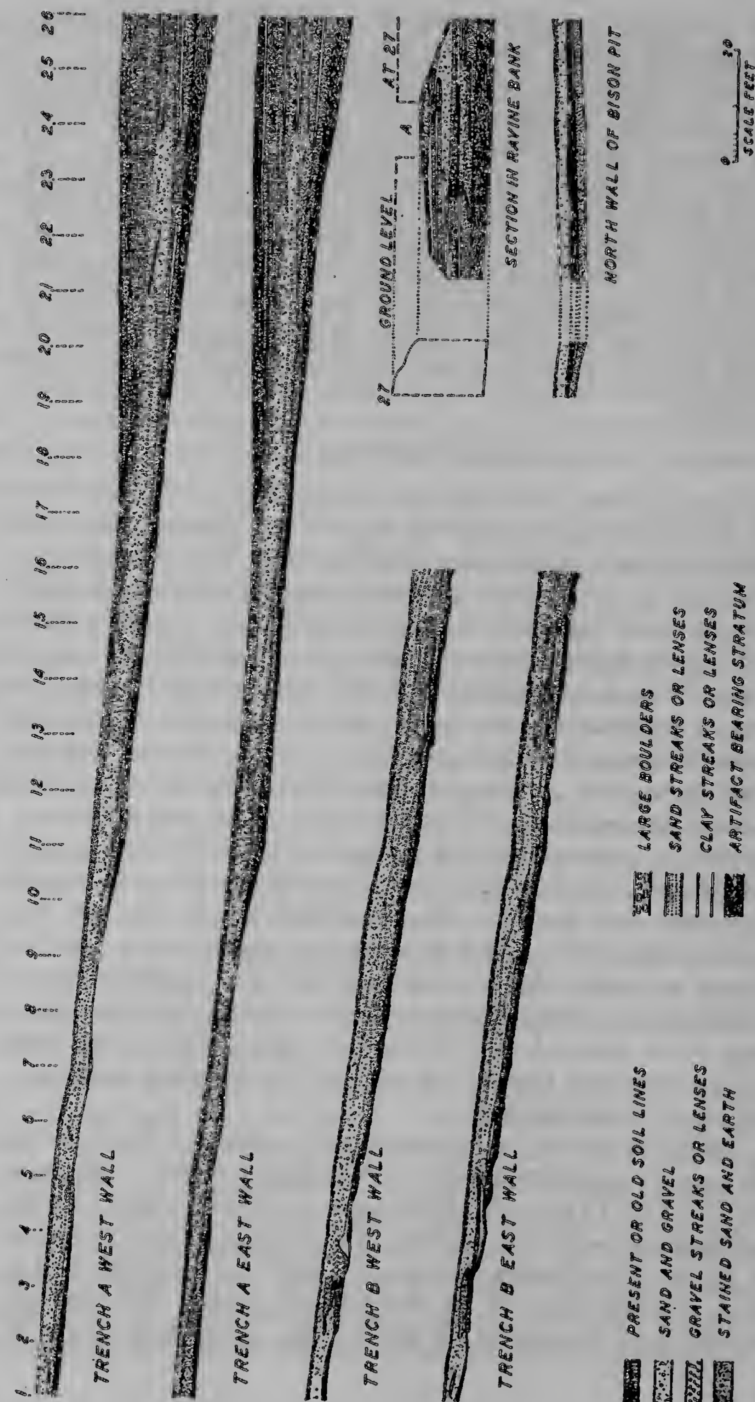


FIG. 1.—Cross-sections of trench walls, face of deep pit in ravine bank, and sides of bison pit.

bones and artifacts was noted the previous year, the initial pegs were set a short distance from the old excavations. Loose dirt was cleared from the pits and the walls were straightened to correspond to the lines of the proposed trenches. The remaining earth was worked out up to the number 1 pegs. This made possible the starting of each trench with a clear-cut number 1 face. Objects found in the zero sections were so recorded, but the careful drawing of section sides and faces was started with peg 1. At the lower end of trench A there is no drawing of the detail of the fill between pegs 26 and 28. This is due to the fact that the material in those sections was worked back on a 48-foot (14.630 m) face from the deep pit in the ravine bank, and the walls of the big pit did not correlate properly with those of the narrower trench in making a composite diagram. There was little change, however, in the last 20 feet (6.096 m). The main difference was in the deepening of the dark earth stratum in which the archeological objects are found.

The method followed in digging was that of stripping off the deposits layer by layer, from top to bottom, in a single section. The upper strata were removed by the use of pick and shovel. Careful check at various places about the site had demonstrated that the higher levels were so nearly sterile, from the standpoint of artifacts, that it was not necessary to subject them to the same careful kind of excavation as that employed in the specimen-bearing stratum. The latter, which rested upon the top of the hard Oliogocene clay, was dug with small tools, bent awls, hand trowels, etc., and all the earth sifted through screens (pl. 2, fig. 1). The slow, meticulous method of digging had several advantages. There was little danger of breakage, it made possible a careful check of the provenience of each specimen (pl. 2, fig. 2), and it facilitated following the top of the clay bed. A different method was adopted for the last five sections in trench A. This was necessitated both by the increase in the amount of overburden and by the shortening of the time available for the work. In these sections the upper layers were removed by the use of a team, plow, and scraper. The lower levels, however, were subjected to the same careful hand technique used throughout most of the work. The chief drawback to the use of the plow and scraper was in the fact that it prevented the drawing of diagrams of each section face. Some information was no doubt lost because of this condition, but inasmuch as the side walls were diagramed, most of the essential evidence on changing conditions in the valley filling process was obtained from the sections.

In drawing and recording the deposits in each section, all of the animal burrows were noted. Even though many of them had long

been abandoned and were completely filled with compact material, they were easily seen. Wherever they occurred in the side walls or faces of the sections, they were included in the diagram. They have not been indicated in figure 1 because they are not deemed essential to the discussion of the valley fill. One interesting fact came out of the check on the animal burrows, however. It has been a common practice on the part of many to discount all finds made in comparatively deep deposits by attributing their location to the work of animals. They explain that the specimens were either carried down by such creatures or fell into holes made by them. Out of a total of 983 burrows, only 1 contained an implement. When it is borne in mind that 750 implements were recovered, the extremely small percentage for such an occurrence becomes apparent. Furthermore, indications were that the animal concerned had been attempting to remove the stone from the burrow and that it had been unable to do so. Those who have excavated in the Southwest, where sites riddled by prairie dogs are a common feature, have frequently noted that the animals will bring objects to the surface but that it is extremely rare to find specimens carried down into the lower reaches of the burrows. The figures from the Lindenmeier site certainly show that the " animal burrow argument " against the authenticity of finds in low levels has been considerably overemphasized.

Trench A, the completed one, did not exhibit as many complicated features in its upper or shallower sections as did trench B. Nevertheless, there were several worthy of comment. The dark, artifact-bearing stratum disappeared toward the end of section 4 and did not appear again until the work had penetrated into section 9. The soil covering over the tufaceous base had been removed by some agency, presumably wind, prior to the deposition of the upper layers. Despite evidences of a small stream channel cutting across sections 6 and 7. the erosion does not seem to be attributable to water action. The top of the clay bed gave more the appearance of a wind-scoured surface. As a matter of fact the bottom of the trench followed across the summit of a ridge in sections 5 to 9. This ridge had run at an angle to the line of the present valley and is quite apparent in the bank of the ravine down stream from the pit where trench A cut into the gully. Test holes were sunk in the floor of the trench in these sections to make certain that the black stratum did not go below the clay and that the latter was actually the top of a ridge and not a lens laid down subsequent to the deposition of the specimen-bearing layer. The few artifacts and stone chips found in this part of the trench were lying directly on top of the basic stratum. As a further check on the situation

a smaller trench was dug through the area east of sections 3 to 5. This work revealed that the artifact-bearing layer there was on a slope dropping away from the ridge.

The black layer appeared again in section 9 and continued unbroken, though varying in thickness from section to section, through to the ravine. At first it was thought that the greater depth of the cultural layer in sections 10 to 13 was due to the washing down of material from the area above. Evidence of water action was not apparent, however. There undoubtedly was some drift from the higher ground but not in sizeable quantities, and the increase in thickness may possibly be explained by the fact that the black stratum overlay a slight declivity in the top of the old clay bed in sections 11 and 12.

The lower sections in trench A demonstrate clearly the factors involved in the filling of the old valley and the raising of the surface level from that occupied by the makers of the implements to the present top of the ground. There are numerous layers of water-deposited material and evidences of the shifting of intermittent stream beds. Various soil lines indicate intervals when conditions were static and vegetation flourished unhampered by material carried down from the higher slopes. In the upper levels of sections 17 to 22 an old stream bed is clearly shown. It was cut, the water course shifted, and the channel filled before the present ravine became a feature of the terrain. Despite the fact that conditions in the West are such that cutting and filling may take place at a rapid rate, considerable time is probably represented by the accumulation in the valley bottom.

A few interesting things may be noted regarding the occurrence of specimens. The most prolific sections in the yield of implements were 12 to 16, the greatest number coming from 16. The largest amount of chipper's debris centered in 13, 14, and 15. In section 15 one series of flakes totalling 111 was found in a 4-inch (10.16 cm) radius, with 78 of the chips in a single pile. Nearby were some hammerstones, and several broken implements occurred in the material from the section. All the fragments from these implements were obtained, and it was possible to restore them. In the lot was a Folsom point represented by two pieces found 4 feet (1.219 m) apart. Section 14 yielded the only definitely worked piece of bone, a thin disk with a series of lines cut around the edge. The percentage of implements by sections is as follows: 1, 3.6 percent; 2, 5.3; 3, 2.5; 4, 1.1; 5, 1.1; 6, 0; 7, 0.4; 8, 0.4; 9, 1.8; 10, 3.6; 11, 3.6; 12, 7.8; 13, 10.6; 14, 7.5; 15, 8.5; 16, 14.5; 17, 3.6; 18, 3.1; 19, 3.6; 20, 0.4; 21, 1.1; 22, 0.4; 23, 2.1; 24, 2.1; 25, 6.7; 26, 4.6. The material from the deep pit in the ravine bank is not included in these figures because the work done there was

not on a comparable basis. However, the yield per square foot in trench A was greater. The proportions average 1 specimen to 0.9 square foot for trench A, and 1 specimen to 6.5 square feet for the pit.

Cut and split animal bones occurred in sections 1, 10, 11, 12, and 16. Those in 10, 11, and 12 did not constitute a continuous deposit through the three sections. In 10 the bones extended across the trench from the middle of the section to within a few inches of the face of number 11. In the latter they were along the west wall in the half towards the face of 12. Those present in the bottom of 12 started 1 foot (30.48 cm) beyond the face of the section and continued for 6 feet (1.828 m) along the east wall. The lens extended into the trench 2 feet (60.96 cm) from the east wall. The bones from the first sections were very fragmentary and in a poor state of preservation. Those in 10 were in better condition and indicated that they came from several young bison. The implements and chips of stone in the section were intermingled with the bones. In section 11 were numerous small fragments, most of which show the effects of burning or at least are partially charred, and a number of bison foot bones which had been split. Several large stones, hammers and choppers, accompanied the bones. The material in 12 consisted of exceedingly scrappy fragments, presumably bison but too shattered for identification. Section 16 contained a few scattered pieces which appear to be from the leg bones of a bison.

The bottom of trench B had a more gradual slope than did the bottom of A, owing to the fact that the ridge which crossed A in its sections 5 to 9 was not present in B. Trench B ranged in depth from 3 feet (.914 m) at the upper end to 7 feet 6½ inches (2.298 m) at the face of section 16, where work was stopped. Sections 1 to 7 (fig. 1), trench B, gave distinct evidences of the channel of a small stream that formerly meandered down the slopes across that portion of the terrain. The flow was probably intermittent, water being present only after heavy rains or when the snows of winter were melting, and consisted of the run-off from the higher ground above the site. The runlet had changed its course and size several times. Originally it had swung in a slight curve from west to east through section 2 to section 1. Owing to subsequent filling and widening, it moved down the slope to section 3, where its course turned to such an extent that it followed the direction of the trench through sections 4, 5, and 6. In section 7 it swung off toward the west again and passed beyond the bounds of the trench. Considerable quantities of clay were deposited in the channel, and after it had become appreciably shallower the water again began to cut, although it formed a much smaller bed along the

course of the older one. These features do not show as well in the diagrams of the trench walls as they do in the drawings of the section faces, which are not reproduced in this report, but study of sections 2 and 3, figure 1, will show their beginnings as they appeared in the walls. The significance of this old stream is that its original channel was cut after the deposition of the soil layer which contains man-made objects and that it removed this dark stratum as it progressed. Furthermore, the channel and its history as briefly sketched provide evidence that there was a higher and more extensive ridge above the site than that of the present day. Now there is not sufficient run-off, even after the heaviest rains, to form such a course. Numerous sand and gravel lenses scattered along the length of the trench demonstrated the occurrence of subsequent washes which carried material down from the higher slopes. With the exception of sections 13-15 there were no clear-cut channels, however. Those sections showed that a wide, shallow stream had crossed that point after considerable material had been deposited above the old occupation level.

In trench B the largest showing of specimens was in sections 7 through 10, although 1 through 5 had a consistent yield. The percentage dropped in 6 and then swung upward to the peak which was reached in 9. It then dropped off to section 12 which contained no implements, although some chips and flakes were found there. From this point to the end of the trench there was a gradual increase in returns, but the yield was not as good as in the earlier sections. In section 5 the black layer on either side of the channel contained a number of large nodules and flakes. None were found in the channel, however. On the west side of the trench at the lower end of section 12, just below peg 13, was a shallow, saucer-shaped depression in the top of the old clay bed. The concavity held a quantity of charcoal and suggested that it might have been a shallow fire pit, although the underlying clay showed no signs of the effects of heat. It is possible that a small fire burning for a short time in such a pit would not cause sufficient discoloration to remain over a long period of years or that such reddening as did take place was subsequently leached out. There were some small fragments of burned bones in the charcoal and around the borders of the basin. The lens of charcoal extended into section 12 a distance of 2 feet 6 inches (76.20 cm). It did not appear in section 13. It projected into the trench for 2 feet (60.96 cm) in section 12. The percentages of implements for the various sections in trench B are as follows: 0, 1.7 percent; 1, 7.9; 2, 6.2; 3, 5.2; 4, 7.1; 5, 6.2; 6, 1.7; 7, 7.9; 8, 15.8; 9, 17.5; 10, 9.7; 11, 4.4; 12, 0; 13, 0.9; 14, 2.6; 15, 5.2.

Bone fragments were not as plentiful in trench B as in trench A; also, the pieces found were as a rule smaller and more fragmentary. Material of this type came from sections 1, 7, 8, 9, 12, 14, and 15. Sections 7 and 12 contained numerous burned and partially charred pieces. An interesting correlation is suggested by the occurrence of the many burned fragments in trench A, section 11, and trench B, section 12. These two sections were located along the same contour line, and their bottoms, the old occupation level, had only a slight slope so that the original surface would have provided a comparatively flat area, a place suitable for camping purposes. The presence of charcoal in the concavity in the old surface in section B-12, the burned bones in both B-12 and A-11 together with the large stones and choppers in the latter—as noted in the discussion of trench A—constitute good evidence that the makers of the Folsom points had actually tarried for a time along that portion of the slope. If the trenches did not cross a portion of the real campsite, they at least bordered upon it. This is further substantiated by the fact that subsequent sections in A were those from which the most specimens came.

In discussing the big pit in the ravine bank in the preliminary report, mention was made of evidence indicating that small ponds or marshy places had been scattered over the old valley bottom.[4] It was suggested that the deep level seemingly constituted the peripheral vestiges of one such spot, the main portion of which was washed away when the present ravine, possibly an older one also, was formed. Information gleaned from the lower sections of trench A corroborates that conclusion as well as the suggestion that the archeological objects obtained there represent midden material that was deposited along the edges of a shallow pond or slough. Some of the specimens no doubt drifted down from the higher levels and others may have been tossed out to sink through the mire to the top of the clay stratum where they are found today. They were not dropped on an occupation level, as were those from sections 12-16, because from section 23 through to the ravine the black stratum gave every indication of an underwater deposit of the kind generally associated with bogs.

The valley fill, as revealed in cross-section by the trenches, shows that the old level of occupation consisted of a soil layer, several inches in thickness, resting on a tufaceous substratum, a Tertiary deposit dating from the Oligocene. The soil layer probably was produced by the natural decay and break-up of the top of the Oligocene bed and subsequent growth of vegetation over the area. There was no evidence

[4] Roberts, 1935, pp. 11, 14.

of deposition by water. No information was obtained to indicate what agency was responsible for the original scouring of the valley and removal of material down to the Oligocene stratum or when such action took place. After the abandonment of the location by its human inhabitants, material from the higher levels was washed down across the site. The first layer to be deposited consisted of stained sand and earth, presumably occupation level material from the upper slopes. This in turn was covered by sand, gravel, and boulders swept down into the valley from its bordering hills. Then the alternating periods of erosion and building up set in as demonstrated in the lower sections of the trenches. As previously stated, all of this change could not have been extremely rapid here because ridges which contributed to some of the valley fill have since completely disappeared, being weathered away in the opposite direction. Furthermore, there are good indications that the central portion of the valley, which lies to the north of the ravine and the archeological site (map 1), now consists of secondary fill. The material which raised the old bottom to the level represented by that above the deep pit was subsequently washed away and the area again built up with sand, gravel, and rocks carried down from the ridges to the west and north of the site. That the original fill, represented by the deposit above the deep pit and the artifact bearing stratum in the area crossed by the trenches, was not disturbed may be attributed to the fact that it was far enough up the opposite slope to escape forces at work on the floor of the valley. This feature is one, however, which belongs more properly in Dr. Bryan's discussion of the geology of the site and will not be considered further at this point. The geologic report will appear in a later publication on the work at the site.

THE BISON PIT

The excavation where the bison bones were uncovered measured 20 feet (6.096 m) by 47 feet (14.326 m) (map 1). Owing to erosion by wind and water, as mentioned in an earlier paragraph, the deposit was not as deep as in the area where the trenches were dug. The bones ranged in depth from 10½ inches (26.67 cm) at the upper side of the pit to 3 feet (.914 m) below the surface along the lower side. The position of the strata here differed slightly from that observed in the main trenches. The object-bearing layer did not consistently follow the clay substratum. It rested upon a bed of stained sand and earth which in turn lay directly on the clay. A wholly satisfactory explanation for this condition was not obtained from the digging. The best suggestion which can be offered at this time is that the particular

animals were killed before a definite dark soil layer had been built up. Some of the bones extended down into the stained stratum. Exposure of a larger section in this area is probably essential to an understanding of the various factors responsible for the situation. The deposit above the bones was similar to that in the upper layers of the trenches, namely, sand, gravel, and some boulders, with a thin soil line at the present surface.

At least nine individual bison are represented in the collection from this location. Many of the bones, including several legs, were still articulated when uncovered (pl. 3, fig. 1). The remains of one creature were found with a forequarter, most of the ribs from one side, and the vertebral column still intact. The skull, in a somewhat damaged condition, was nearby. Portions of other skulls were obtained, but they are all too fragmentary to be of material assistance in the identification of the species. The most striking find consisted of a vertebra with the tip end of a projectile point in place in the foramen for the spinal cord (pl. 3, fig. 2). This bone was in position in the center of a group of articulated vertebrae, and when it was removed from the ground and was being cleaned by L. C. Eiseley, graduate student from the University of Pennsylvania, the point was discovered. Hafted on either an arrow or spear shaft, it had apparently been driven into the animal and then broken off at the end of the longitudinal groove. The wound may not have been directly responsible for the creature's death, but it would have crippled it to such an extent that a killing blow could easily have been administered. This was not the only implement from the pit, however, as 33 additional specimens of the stone chipper's work were found in association with the bones. These objects consist of points, portions of points, various types of scrapers, blades, flakeknives, and gravers. Two flakes with chipped cutting edges accompanied the bison skull, and several fragmentary points were lying between components of articulated segments in such a way as to suggest that they had been in the flesh of the animals.

The assemblage in the bison pit recalled in some aspects features observed at the quarry where the original Folsom finds were made.[5] Evidence at the latter place indicated the culmination of a hunt and the killing of animals around a water hole or marshy spot. After as much of the flesh as could be carried away had been removed from the carcasses, they were left to sink in the mire. Through the course of time natural agencies drained the swampy ground and covered the site with earth washed down from higher levels in the vicinity. No

[5] Cook, 1927; Figgins, 1927.

traces of an occupation level or camp were found at Folsom—only the signs of the kill. In this respect it was like the bison pit. Since most of the material scattered over the Lindenmeier site is so scrappy in its nature, the discovery of partially articulated skeletons and numerous whole bones was fortunate. Just why the dismemberment of these animals had not been carried to completion can only be postulated. They may have been killed shortly before the group moved from the site and only such portions taken as could be disposed of immediately. The camp possibly was oversupplied with meat and as a consequence only the hides and choice cuts were removed. Then again, they may represent a winter kill when pelts were the chief objective, the winter coat being superior for robes or blankets.[6]

There is no evidence to show the manner of hunting or methods of butchering. It must be borne in mind, however, that the period here represented long antedates the era of the horse in North American Indian cultures and that the chase had to be conducted on foot, the practice in vogue among later peoples when encountered by the first Spanish explorers in the Southwest.[7] This custom probably called for greater cunning and skill, if not actual bravery, than did the method of hunting after the horse became a prominent accessory in the Plains cultural pattern. It was necessary for the hunter to get close enough to the bison to use his stone-tipped weapons with success. By analogy, on the basis of later customs, it may be suggested that Folsom man erected brush-shelters or blinds close to the ponds and watering places frequented by the bison and bagged the creatures from ambush. Vicente de Saldivar Mendoca observed such a practice when he visited the buffalo plains in 1598 as sargento mayor of the Oñate expedition.[8] It is also possible that the hunters camouflaged themselves in a manner similar to that reported at a much later date by Catlin. He described the way in which Indians covered themselves with wolf skins and crawled on hands and knees to within a short distance of the desired game and then killed it.[9] Wolves were numerous and commonly followed the herds of buffalo, the latter paying little attention to their presence.[10] Bones from the wolf were found here, so that hunting in that fashion was not beyond the range of possibility.

Butchering an animal the size of those represented by the material from the bison pit would not be an easy task. It seems obvious that

[6] Catlin, 1841, vol. 1, pp. 253-254.
[7] Espinosa, 1933, p. 157.
[8] Bolton, 1916, p. 230.
[9] Catlin, 1841, vol. 1, p. 254.
[10] Winship, 1896, p. 528.

the skinning and cutting up of the meat must have been done where the slaughter took place, in this instance at no great distance from the camp. The situation at the time of occupancy would have been favorable to the brush-blind type of hunting. A slough or marshy spot had existed in the old valley floor not far from the point where the bones were found—this was demonstrated in one of the Denver Museum test pits. A screen placed on the slope above would have made an ideal place to await the coming of the bison. The nature of the soil layer indicated that there was fairly heavy vegetation around the water hole, probably coarse grass and reeds, which would protect the meat from dirt and sand during the process of skinning and cutting up an animal killed at this place. The handling of the carcass no doubt presented a problem of some difficulty, as there were no mechanical means for transporting it or to facilitate turning and lifting. Such work had to be done by manpower alone. The only tools available for the dismembering operation were those of stone or perhaps bone.

The nearest approximation to the description of such an undertaking is probably that by Castañeda. The latter was the chronicler for the Coronado expedition, which penetrated into the buffalo area in 1540. Members of that party had an opportunity to observe the Indians under conditions comparable to those of earlier centuries. In his account of the skinning of the bison Castañeda said: "They cut the hide open at the back and pull it off at the joints, using a flint as large as a finger, tied in a little stick, with as much ease as if working with a good iron tool." [11]

Other documents, one attributed to a friar accompanying the Coronado party,[12] one by Luxán,[13] and Fray Juan Augustin Morfi's History of Texas,[14] give good accounts of the use to which various parts of the animal were put. The skins were employed in the making of tents, clothes, footgear, and rope. The sinews were used to make thread for sewing their clothes and tents, and for wrapping shafts. The stomachs served as pitchers and vessels, the intestines as containers of fat and of marrow. Awls were made from the bones. The horns were cut into spoons, cups, and ornaments. The hoofs were converted into glue to aid in fastening projectile points in shafts. The brains were used in tanning and softening the hides. In view of all this, it is little wonder that the bulk of the bone material from the site consists of scraps and splinters. Even in the bison pit, which

[11] Winship, 1896, p. 528.
[12] Winship, 1896, p. 570.
[13] Hammond and Rey, 1929, pp. 120-121.
[14] Castañeda, 1935, p. 67.

contrasted sharply with other portions of the site, many of the bones were cut and split, and several of the skulls had been battered and chopped into small pieces.

The bones from the bison pit were submitted to Dr. C. L. Gazin, assistant curator of paleontology, United States National Museum, who kindly furnished the following notes:

The Fort Collins material represents an extinct species of bison and should probably be referred to *Bison taylori*. The horns of the skull are very incomplete, but from the size of the proximal portions of the horns, the breadth of the cranium, and the length of the rostrum it is clearly not a living type.

Comparisons are handicapped by lack of comparable fossil material in our collections outside of Alaska and Minnesota. It has been necessary to rely largely on published illustrations and descriptions of the numerous bison which have been designated as distinct species. It is obvious that too many names have been applied to North American bison and some of the older types are hardly adequate for clear diagnosis. Several of the known species are eliminated in comparisons, however. The Fort Collins material apparently could be referred with equal readiness to *Bison occidentalis, Bison taylori*, or *Bison oliverhayi*, among those which remain, and there seems to be some doubt as to the validity of one or more of these.[15]

The skull resembles, and approximates in size, a skull from Kansas identified by Lucas as *Bison occidentalis*, which was the first reference to this Alaskan species of material from the United States proper. This determination by Lucas probably furnished the basis for continued recognition of the species in the middle western region. The Fort Collins skull is intermediate between the types of *Bison taylori* and *Bison oliverhayi* from Folsom, N. Mex., in breadth of the cranium at the postorbital constriction, but the entire length of the skull is as great as, or perhaps somewhat greater than, that of *Bison taylori*. Unfortunately, the incompleteness of the horns obviates detailed comparisons of these structures; however, the greatest diameter of the basal portion of either horn about equals that in *Bison taylori*. Characters of the teeth which have been used to distinguish species of bison are of doubtful value and do not help in the present case.

The proportions of most of the limb elements are slightly less than the measurements given by Hay and Cook for *Bison taylori*, although a few of the foot bones are larger in their respective measurements. The various limb bones and vertebrae, other than indicating an animal of distinctly large size, are of little or no diagnostic value in determining the species.[16]

ARTIFACTS

The specimens collected from the excavations consist of points, scrapers, gravers, chisel-gravers, choppers, large blades, flakeknives,

---

[15] The scrap bones secured in the autumn of 1934 were identified by J. D. Figgins as being from both *Bison taylori* and *Bison oliverhayi*. See Roberts, 1935, p. 31.

[16] For a discussion of *Bison taylori* and *Bison oliverhayi* see Hay and Cook, 1930, Figgins, 1933.

hammerstones and rubbing stones, and worked bones. Pieces of hematite show the effects of having been rubbed for pigment. There are numerous flakes, too nondescript in character to be called implements, which exhibit signs of workmanship. The collection also contains a large number of channel flakes, the long spalls removed in the fluting of the projectile points. Varieties of stone represented in the implements are jasper, chert, chalcedony, moss-agate, quartzite, petrified wood, geyserite, limonite, granite, quartz, and sandstone. Most of the chipped tools, the cutting and penetrating implements, were made from the chalcedony, chert, jasper, moss-agate group, the " flint " of the amateur collectors. This type of material is well adapted for use in tools and wherever available constituted the preferred stone of the implement fashioners. The harder quartzite and petrified wood were employed but, in addition to being more difficult to work, did not produce as good finished products. On the other hand, they were better for hammers and mauls, and numerous examples show that they, as well as the quartz and granite boulders, were used for that purpose. Sandstone is suitable only for rubbing, polishing, and sharpening bone tools and was so employed at this site.

The percentages of specimens found at the various places where excavations were made is as follows: Trench A, 37.6 percent; trench B, 15.2; the big pit in the ravine bank, 17.5; the bison pit, 4.4; the small trench east of sections 3-5, trench A, 10.7; miscellaneous, scattered surface finds and specimens scratched out in prospecting along terrace edge and ravine bank, 14.5.

POINTS

There is an interesting range in the size and variety of points (pl. 4). This group constitutes 11.3 percent of the specimens in the collection. The predominant type of point is the characteristically fluted Folsom in its two forms, the long and slender one with tapering tip, and the short, broad style with the maximum breadth of blade occurring close to the tip end.[17] Although most of the specimens are fragmentary examples, there is sufficient material to show that the two forms were about equal in number. The short, stubby examples, designated form A in the preliminary paper, range in size from one with a length of 22.5 mm, breadth of 14 mm, and thickness of 3.5 mm, to one with a length of 70 mm, breadth of 35 mm, and thickness of 6 mm. The long, slender specimens, the B form, have a range between one with a length of 23.5 mm, breadth of 13 mm, and thickness

[17] Roberts, 1935, pp. 15-16, fig. 2.

of 2 mm, and one with a length of 60 mm, breadth of 23 mm and thickness of 4 mm.

The preponderance of broken specimens found at most sites has been pointed out by numerous writers. In the 1935 series from the Lindenmeier site the situation remains unchanged, as 87 percent of the points are only fragmentary examples. In general this condition may be attributed to the brittleness caused by the fluting. The removal of the longitudinal flakes from each face so thinned the points that they became extremely fragile. At the present site, however, two other factors must be considered, namely, that many points were broken in the making, and that the collection contains specimens which were never completed. The purpose of the grooves is not known, although a number of explanations have been made to account for them. It has been suggested that the fluting was to facilitate hafting, the split end of the shaft fitting more snugly into the grooves than it would if the point had a convex basal surface. Other interpretations are that it was to improve the penetrating qualities, to permit the head to break off in the animal, to allow the head to slip out of the foreshaft, to promote bleeding, and to reduce the weight. No doubt a number of such ideas influenced the development of this typical feature. The most important, however, in the opinion of the present writer pertain to the quality of penetration and the hafting.

The method of shaping and chipping Folsom points was discussed at some length in the previous report and need not be described in detail in this paper.[13] It will suffice to say that the evidence from the recent work substantiates that of the preceding season and corroborates conclusions drawn from it. These conclusions were that the points were first shaped, then the channel flake was removed by indirect percussion applied to a nubbin or small "seat" left in the center of the concavity when the base was chipped. Finally, the edges were retouched. The 1935 material adds one significant factor, however, which was suggested by the earlier specimens, but the evidence was not conclusive enough to warrant its mention in the preliminary report. This factor is that the tip was left in a roughly rounded state, not pointed, until after the channel flake was removed. Its shaping constituted a part of the secondary chipping by which the edges were refined. Several specimens in the new series definitely show this to have been the practice. Two examples, both broken into several pieces in the process of manufacture and tossed aside uncompleted, clearly demonstrate the feature.

---

[13] Roberts, 1935, pp. 18-21.

The broken material from the 1935 work contains more tip ends than that of 1934, although the butt ends still comprise a large percentage of the series. Most of the tip ends came from the bison pit, and the inference is that they had been embedded in the flesh of the animals whose bones were found there. In discussing the prevalence of butt ends in the previous finds it was suggested that the circumstance could be attributed to the replacing of damaged points. Many must have snapped off in the killing of game. This is illustrated by the tips in the bison pit and by the one in the vertebra. Undamaged shafts were no doubt retrieved and carried back to camp to be fitted with new points. The fragment of the old one remaining in the shaft would be the butt end, and in the remounting process it would be tossed aside to remain in the debris of accumulation. Such an explanation, of course, refers only to fragments which show that they formed part of a completed point; it would not apply to butts from those broken in the making. The basal portions were not always discarded, however, as examples in the collection show that it was not an uncommon practice to take a butt which had lost its tip and rechip it so that it again had a point capable of penetration. Specimens in this group are extremely stubby and flat-pointed.

There are a number of points in the collection which are not of the characteristic Folsom form. One type in the variant group consists of small points made from fortuitous flakes, often from portions of channel flakes. None of these has the fluting; as a matter of fact, they are too thin to permit the removal of a side spall. They definitely belong in the implement complex, however, and their outlines closely follow the general Folsom pattern. The other type of point is represented by fragments only, but the pieces are so distinct in their nature that they must be considered as representative of a form found in the West which is frequently linked with the Folsom. This is the so-called Yuma. The fragments are from the true Yuma, not from any of the multitudinous subtype varieties. The typical Yuma point, in the conception of the writer, is one which is long and slender. The edges extend approximately parallel from the base—in some cases there is an almost imperceptible narrowing toward the butt—for about two-thirds of the length and then taper to a sharp point (fig. 2). It is oval in cross-section (fig. 2, *b*). The base may be straight across, slightly concave, or deeply concave. Sporadic examples have a small shoulder on one or both sides near the base, thus forming a slight tang (fig. 2, *f*). In the shaping process the main flakes were removed so that the facets extend completely across the face of the blade, usually at a slight angle directed toward the tip. The edges were then

refined by a retouch in which minute flakes were removed, a process comparable to the secondary chipping in the Folsom group.

A large variety of blades and points have been grouped under the name Yuma, and at the present time there is considerable confusion as to what constitutes such a point. In fact it seems that the tendency is to call anything Yuma that is not a true Folsom or a barbed and tanged arrowhead of the recent Plains type. Dr. E. B. Renaud, of the University of Denver, was the first to describe the form and gave it the name Yuma. His discussion and classification, including his several subtypes, may be found in his various publications.[19] Dr. E. B. Howard considers the Folsom-Yuma problem at some length in his "Evidence of Early Man in North America,"[20] and J. D. Figgins has written a number of articles on the subject.[21] As the situation

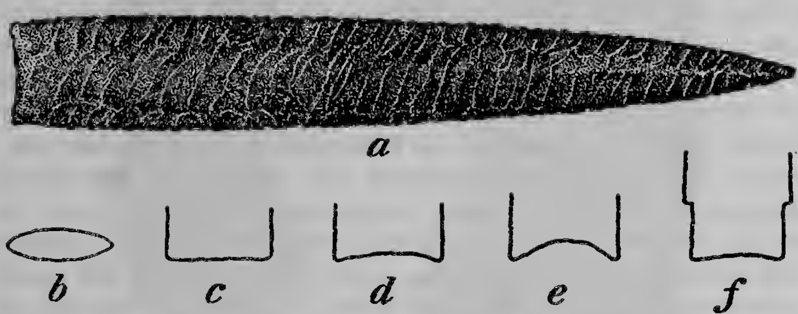


FIG. 2.—Yuma point, *a*; Cross-section, *b*; and base types, *c-f*. (Actual size.)

stands today, it seems essential to reach an agreement on what is meant by Yuma and that its use be restricted to something more specific than its present catch-all connotation.

The importance of the fragments from Yuma type points found at the Lindenmeier site lies in the evidence bearing on their position in the sequence. One came from the latest old stream channel in section B-3. Its position distinctly indicated a later deposition than the black stratum containing the Folsom points. The other specimen came from the black layer. This was in A-23, where indications were that the layer was the bottom of a swamp or bog deposit. The exact position of this example was not obtained, as the point was found in the screen and not in situ. Indications were that it had been in the black fairly high above the contact. Since this cannot be established with certainty, it will be considered as being on a level with the Folsom

[19] Renaud, 1931, 1932, 1934.

[20] Howard, 1935.

[21] Figgins, 1934, 1935.

material. Portions from two other points, not typically the true Yuma type as described in this paper but of a form usually called Yuma, were also obtained. One was above the black layer in section B-8. The other was above the black in the area just east of A-4. The situation may then be summarized as follows: Out of four specimens attributed to the Yuma group, one was in a position that may be regarded as evidence for contemporaneity with the Folsom, and three were later.

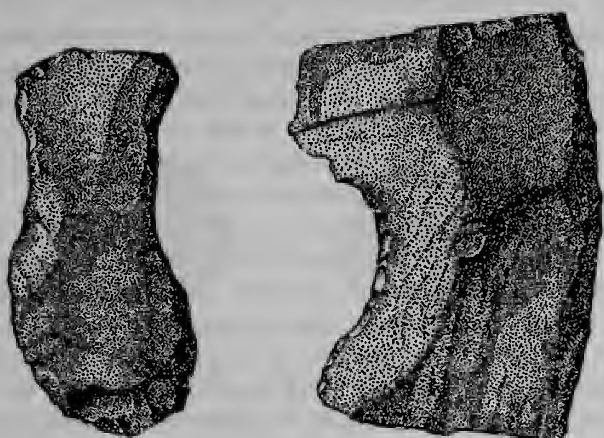
The Denver Museum party obtained, in its large pit, four specimens which in a broad sense of the word might be called Yuma. Two of these were from the contact line between the black and the basic substratum. The others were from a higher level in the black. The situation in the deposit where these were found was similar to that in trench A from section 23 through to the deep pit. As a consequence there is the possibility of somewhat later material sinking to a lower level. The only conclusion which can be drawn from the evidence as it now stands is that there was at best only a late contemporaneity between Yuma and Folsom at the Lindenmeier site with a later survival of the Yuma. Subsequent work may throw more light on the subject and change the picture, but at present the Yuma must be considered comparatively late in this immediate district. Furthermore, they are only a minor factor, as only .05 percent of the points from the site can be classified as Yuma, and some of these are of such a nature that their inclusion is highly debatable.

SCRAPERS

Implements of this type comprise 32.8 percent of the collection from the 1935 excavations (pls. 5, 6, 7, 8). The tools fall into several major groups. These are the side scrapers, "snub-nosed" scrapers, end scrapers, "thumbnail" scrapers, and scraper edges. The latter consist of pieces from broken implements too indefinite in character to warrant inclusion in one of the other classes. The term "thumbnail" is occasionally used as a synonym for "snub-nosed." In this discussion they are regarded as different types.

The side scraper series represents 56 percent of the group. There is considerable variation in the type of flakes used in their manufacture, their degree of finish, and in their general quality. Some of the implements are light in weight and almost as thin as a sheet of heavy paper. Others are thick and cumbersome. Certain examples are little more than rough flakes with a worked edge along one side only; in some cases merely a portion of the edge shows chipping. Tools in this

group frequently retain part of the siliceous crust of the nodule from which the flake was struck. In contrast are those which display careful workmanship not only of the edges but of the faces as well. The scraping edges, regardless of the quality of the tools, are straight, convex, or concave. Good examples of the concave form are illustrated in figure 3. Several of the implements combine both straight and convex, concave and convex, or all three types of edges. It is possible to separate the side scrapers into a large number of subforms, but for the purposes of this paper the general grouping just described is sufficient.



a *b*

FIG. 3.—Side scrapers with concave cutting edges. (Actual size.)

The "snub-nosed" scrapers are an interesting series and are perhaps the most consistent in type of all the tools in this general category (pl. 8). They comprise 26.6 percent of the scrapers. Despite the fact that there are a number of subforms, the implements, whether large or small, made from good stone or poor, show no marked deviations from the main pattern. All are characterized by one thick, rounded, convex, carefully chipped end. The treatment of the other end, the edges, and the lateral faces varies. Some are untouched, on others the sides were chipped, others show the use of the flaking tool on the lateral faces. Rarely was the bottom of the tool, the ventral surface or side which came off the core, altered in any way. The size range in this group is rather pronounced. They vary in length from 21 to 50 mm, in breadth at the cutting edge from 18.5 to 40 mm, and in thickness from 4.5 to 12 mm.

The end scrapers are more variable and nondescript in form than the types just described. They constitute only 2.4 percent of the series, which might be taken as an indication that they were not as widely used as the other forms. Such was not necessarily the case, however, as numerous implements included in the side scraper class because their predominant features pertain to that form also have an end scraper. So far as shape is concerned, this tool adheres to no particular pattern. Any random flake seems to have sufficed for such an implement. Its main feature is a scraping edge at one or both ends of the flake. The sides and lateral surfaces generally remain untouched. The ends differ from those of the "snub-nosed" group in that they are not thick and bulky, but are more chisellike in form. They are either straight across, slightly convex, or have a sweeping curve not unlike present-day blunt-end table knives. The size range varies between an example with a length of 35 mm, a breadth of 18 mm, and a thickness of 5 mm, and one with a length of 48 mm, a breadth of 23 mm, and a thickness of 4 mm.

The "thumbnail" scrapers are not numerous in the collection. Only 1.6 percent of the scrapers are listed under this classification. They constitute a definite type, however. The name is derived from the close resemblance between their shape and that of the ordinary thumbnail. They are thin, roughly rectangular in outline with a convex scraping edge. Fragments from channel flakes seem to have been favored as material from which to make these implements. The size range is not great. Examples in the collection are from 14 to 15 mm in width, 15 to 17 mm in length, and 2 to 3 mm in thickness.

The broken series or scraper edges comprise 13.4 percent of the scraper group. Most of the specimens are probably portions of side scrapers, but as previously mentioned they are not sufficiently clearcut in form to warrant more definite classification.

A curious implement, the only one of its kind thus far found at the site, is one which can be termed a core scraper (fig. 4). It was made from a small core, not from a flake as were the majority of the tools. The long, slender facets where chips were removed in the shaping process show that the maker was possessed of great skill. Whether the object was the product of a bit of experimental work or belongs to a definite, although minor, type is a question which can be answered only by additional digging. If no other examples are found in a comparable series of specimens, it unquestionably should be considered unique. Core scrapers have been found in parts of Alaska and in some sections of Siberia. This implement is not correlative to the types from those places, however, and it may be that in the last

analysis it should be regarded as an aberrant form of end scraper or "snub-nosed" scraper.

One type of scraper—the turtleback[22]—found during the 1934 excavations is not represented in the collection obtained in 1935. The failure to obtain additional examples indicates that it must have been a very minor form.

No suggestions as to possible uses for the various types of scrapers have been made in foregoing paragraphs. There is no definite knowledge on the subject, but to judge from the later Indians, such tools must have been absolutely essential in the domestic life of their makers. That they constituted an important part of the implement group is shown by the fact that almost a third of the specimens belong in this category. They no doubt functioned in the dressing of skins, the removing of flesh from bones, for cutting bones, and for the

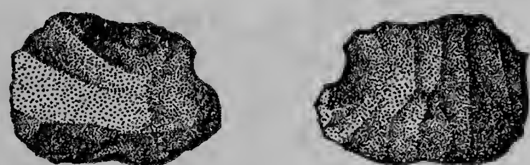


Fig. 4.—Nodule scraper. (Actual size.)

smoothing of spear and arrow shafts. The "snub-nosed" scrapers would be particularly well adapted to the scraping of marrow from split long bones. The convex scrapers, such as figure 3, *b*, are just the type of tool needed in the shaping of wooden shafts.

GRAVERS AND CHISEL-GRAVERS

The tools in these two groups are similar in many respects (pl. 9). Although they are definitely related and the terms used to designate them overlap to some extent, there is a distinction between the specimens in these groups. The gravers constitute 5.6 percent of the collection. They are of particular interest because they suggest that the makers of the Folsom points were also adept at some form of the engraver's art. As yet there is only meager evidence of the character of this type of delineation, but the 1935 investigations established the fact that markings were made on bone and soft stone. Fragments from two objects of polished bone, burned in a fire, exhibit finely cut lines which appear to have been components of some kind of decoration. A bone disk with a series of short grooves bordering the edges

[22] Roberts, 1935, p. 24.

on both faces (pl. 9, *e*), suggests the use of an implement such as one of the so-called gravers. A fragment from a similarly marked bone was found by the Denver party, and a portion of a correspondingly shaped and cut object made from soapstone—found by Maj. R. G. Coffin—shows that materials other than bone were subjected to ornamentation of a type which could be executed only by use of such a tool.

Another possible function for the graver type of point has occurred to the writer, namely, its use in tattooing. This custom prevailed to a greater or less extent throughout the country among the later Indians and may have been one of the traits of Folsom man. The small, very sharp tips would readily puncture the skin for the application of pigment. Unfortunately, the " canvas " on which such designs are drawn is highly perishable, and there is little likelihood of finding direct evidence that tattooing was done.

Most of the gravers consist of chance flakes modified only by the presence of short, needlelike points on one side or end. Any piece of stone, provided it was thin enough, was suitable. Sometimes a channel flake (pl. 9, *a*), was employed, and occasionally a fragment from a broken scraper. On the whole, however, nondescript scraps from chipper's debris were all that the maker required. The small sharp points were not fortuitous: they were definitely chipped. They differ from the usual drill in that one face of the point is flat, and the other is beveled along the edges and has a slight bevel at the tip of the point. Drills are chipped on all sides. The gravers may have from one to five points on a single flake. The implements in this group range in size between one with a length of 19 mm, breadth of 13 mm, and thickness of 3 mm, and another with a length of 55 mm, breadth of 33 mm, and thickness of 6 mm. The actual graver points do not vary greatly in size. They consistently range between 1.5 and 2 mm in length and 1 and 1.5 mm in width at the base.

The chisel-gravers are more definitely shaped than the gravers. They are not as numerous, the type forming only 1 percent of the total collection, but they nevertheless are a distinct tool (pl. 9, *k, l, m*). They also were made from flakes. In contrast to the gravers, the points are broader and more elongated. There is a pronounced bevel on the tip, and the end of the latter is a straight edge, convex on rare examples, rather than a sharp point. These implements exhibit better workmanship than that on the simple gravers. The chipping is not confined to the points but as a rule extends along the edges, sometimes even around the base. The chisel-gravers range from 25 to 37 mm in length, from 13 to 27 mm in breadth, and from 3 to 8 mm in thickness.

The points range between 3 and 10 mm in length, from 4 to 7 mm in width at the base, and from 2 to 3 mm in width at the cutting end.

Both gravers and chisel-gravers are found in combination with other tools. There is a definite group of "snub-nosed" scrapers exhibiting the feature, and not a few side scrapers have one or the other type of point on a side or an end. Such specimens suggest that the small points may have served a utilitarian as well as an artistic purpose, although it is hard to postulate what such a function might have been. Most of them are too small to have served as awls or perforators.

CHOPPERS

Implements of this type are not numerous in the collection, comprising only 0.5 percent, but they form a definite class. They could be considered as variations of the tools generally called hand axes or rough celts (fig. 5, *a* and *b*). To avoid complications in the matter of correlation and chronological implications not necessarily justified, neither of those more common names will be used in referring to such objects. The choppers were made from true cores or from pseudo cores. The latter were originally flakes of more than average size which produced an object exhibiting in all respects the characteristics of a core implement despite the fact that the stone from which it was formed was not a complete nodule. The general shape of the tools suggests the adze or celt of the later Indians. The workmanship was not as good as that on the chipped celts of more recent times. The makers were apparently satisfied with the minimum expenditure of effort needed to make a usable tool. The main outlines were roughed out by the removal of large flakes, and the finer chipping was reserved for one chisellike end. The bases are rough. As there is no trace of rubbing or polish on the stones to indicate that they were hafted, they may have been held in the hand. If so, the butt ends were probably wrapped in a piece of bison skin or similar substance to prevent slipping and to protect the user's palm.

The specimen marked *a,* figure 5, has an overall length of 71 mm. It is 43 mm wide at the base end and 27 mm wide at the cutting edge. The thickness at the base is 28 mm and at the bit 5 mm. Chopper *b,* fig. 5, has a total length of 74 m. It is 39 mm broad at the base and 24 mm wide at the cutting edge. The base is 22 mm thick and the cutting end 3 mm.

Numerous unworked stones which were so shaped by nature as to make efficient choppers were found on the site. That many of these were used in splitting and hacking bones was suggested by the fact

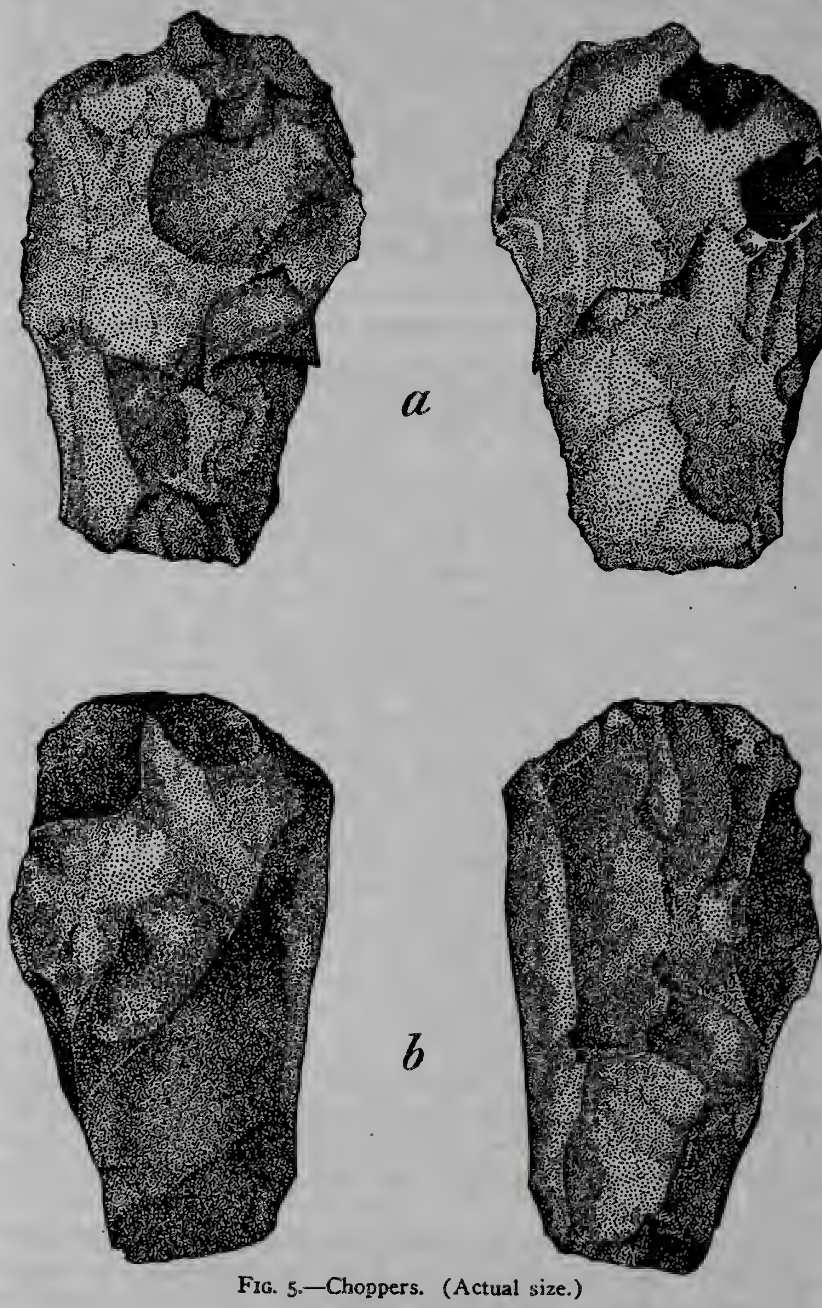


FIG. 5.—Choppers. (Actual size.)

that they were found in association with such objects. Several of these natural choppers also have slightly battered edges, showing that they had been employed as tools.

KNIVES

The specimens which may be grouped under the classification of knives consist of implements made from large, ribbonlike fragments of stone modified only by chipping along the edges; flakes which were more carefully shaped and bear a general resemblance to modern knife blades; and skillfully chipped stones which exhibit typical Folsom features in their fluted faces and secondary retouch along the edges. Tools in this group comprise 3 percent of the collection.

The ordinary flakeknives (pl. 10, *a-f*, and pl. 11, *a-c*) are crude implements, yet would be quite efficient in use. On some of them the chipping is large and irregular, on others (pl. 11, *a*, for example) it is as minute and precise as could be desired. Both convex and concave edges are present in the series. Some of the tools have two types on a single side, others on opposite sides. There is nothing to indicate that any of these cutting edges were hafted in handles, but it is quite possible that some of them were. The flakes range from 37 to 79 mm in length and from 10 to 45 mm in breadth. The thickness varies from 2 to 11 mm.

The group which shows more definite shaping (pl. 11, *d-f*) comprises specimens which exhibit some of the finest chipping noted in the collection. Not all of them were subjected to the same degree of workmanship, but the class as a whole is much superior in finish to the rough flakeknives. It seems probable that most of the blades in this group were hafted. All have an unfinished end, and on a few there is a slight gloss or luster such as a handle might produce. Measurements in this group range between 45 and 80 mm in length, 20 and 28 mm in breadth, and 3 and 8 mm in thickness.

The carefully chipped blades with fluted faces (pl. 10, *g* and *h*) comprise only 18 percent of the knives. So far as craftsmanship is concerned they are comparable in every way to the projectile points. The same technique was employed in their manufacture. Their ends, however, are rounded and blunt. In some cases they were smoothed. The cutting edges tend to be parallel rather than tapering or bulging as in the case of the points, yet such a knife could be converted into a typical point by the mere expedient of chipping the blunt end to a penetrating tip. These knives were undoubtedly mounted in a handle. Blades in this group range from 51 to 70 mm in length, 23 to 31 mm in width, and 4 to 6 mm in thickness.

Knives were also made from channel flakes, or perhaps it might better be said that channel flakes were used as knives. The razor-keen edge of these byproducts would be ideal for cutting purposes. Study of such flakes suggests that they were first employed as struck-off from the face of the point. Then as the edge became nicked and dulled in use it was touched up with the flaking tool.

LARGE BLADES

The tools and fragments from such implements classed under the heading of large blades are leaf-shaped objects which combine both the qualities of a knife and a scraper. This group constitutes 6.3 per-cent of the series. These specimens are suggestive of the so-called blanks of later periods. The latter were the intermediate stage between the original nodule and the finished tool. They were roughed out in the quarry and then carried home to be completed as time permitted. The blades from the Lindenmeier site are actual implements, however, despite their similarity to the blanks. On many of them there is a careful secondary retouch along the edges. Others show minute chipping of the type which results from use. They would have functioned well in the skinning and cutting up of an animal and also in the scraping of a hide. Some of them exhibit a slight rubbing or gloss at the base which suggests the use of handles, while others do not. Even in an unhafted state they would be quite serviceable.

The blades range in size from 55 to 90 mm in length, 35 to 40 mm in width, and 7 to 9 mm in thickness. The majority fall between 75 and 80 mm in length, which might therefore be termed the standard length.

MISCELLANEOUS OBJECTS

Several varieties of specimens are grouped under this heading because they constitute only a minor part of the collection. In some cases there is only a single example of the class. Other objects are not actual tools or implements, yet are an integral part of the general complex. Included in this listing are the worked bones, channel flakes, hammerstones and rubbing stones, and pieces of hematite.

Only a few bones show signs of use or of having been shaped for some definite purpose. Many have cuts and marks made at the time when the flesh was stripped from them or when they were split for their marrow, but this is not considered indicative of workmanship preparing them for some special function. One difficulty in judging the bone material lies in the fact that most of it has been decalcified,

and an accompaniment of this phenomenon seems to be the sloughing of the outer surface. The surface is frequently essential in the identification of a fragment of bone as a tool. A number of chance scraps in the collection could have served as implements, but because the outer surface is gone, the polish acquired through use is missing, and for that reason it can not be stated with assurance that they were tools. Each of these specimens has a tapering, blunt-pointed end like that on punches and awls. Their sides have been rubbed and the base end is rounded, but because signs of usage are absent they cannot be designated as such tools. There is no question but that the people used bone implements, because the collection contains small fragments, preserved by having been charred in a fire, that exhibit the smooth and highly polished surfaces characteristic of awls. The pieces are too small, however, to give any clue as to the size and general shape of the specimens. Two pieces cut from the shaft of a long bone, each with one sharp, well-defined edge, would be serviceable as knives or fleshers. As green bone they would have functioned efficiently either in skinning or in scraping the fat and hair from a hide. The edges of both are slightly discolored and show a trace of polish. Another object suggests that it was the end of a paddlelike scoop. It also was cut from the shaft of a long bone.

The bone disk with ticked edges (pl. 9, *e*) has already been mentioned. This object was probably a marker or gaming die. It cannot be considered as an ornament in the strict sense of the word, as there is no perforation for suspension and no indication that it was attached to any other substance. It seems to have been fashioned from a piece of scapula or shoulder blade. Both faces are smooth, except for the series of cut lines bordering the circumference. This specimen and approximately half of one similar to it obtained by the Denver Museum party are the best examples of worked bone found at the Lindenmeier site. The disk measures 34 by 28 mm, and is 2 mm thick.

The channel flakes form an interesting series because they demonstrate so impressively the consummate skill of the men who struck them off from the sides of the points. The flakes are smooth on one side, the one that formed the groove in the face of the point, and flaked on the other. Some are paper-thin; others are as much as 2 mm thick. One good example from a white chalcedony point is 45 mm long, 13 mm wide, and 1 mm thick. It is unquestionably the complete spall from the channel. One piece of channel flake fits into the groove on one of the butt ends recovered from the site. This is the only example of the flake and the point thus far obtained. Many of the channel flakes were discarded when removed, but others, as men-

tioned in the discussions of the gravers and knives, were employed in some utilitarian fashion before being tossed aside. Every type of material observed in the points or fragments of points is represented in the channel flakes.

The hammerstones are as a rule merely nodules with battered ends. Any chance stone which could be held in the hand and used for striking seemed to answer the purpose, although in a few cases (pl. 12, *i*, for example) the stone was roughly shaped to an oval form. The majority were like *k*, plate 12, however. These objects were probably employed in knocking flakes off large nodules, for cracking bones, and other purposes where a striking implement would be required. Harder types of stone were used for this purpose, and the specimens in the collection are of granite, quartz, and petrified wood. The hammerstones range between 12 and 16 ounces in weight.

The pieces of sandstone in the collection show that they were used as rubbing stones. Many of them have distinctly flattened sides and ends (pl. 12, *a, b, d*). Some of them suggest the small hand stone used by the later Indians in grinding grain, nuts, and other materials, but no mortars or nether milling stones have been found, and it therefore seems that they must have had some other function. As most of the fragments of this type are stained with red pigment, it is possible that they were used to work color into a skin or some other substance. One of the stones (pl. 12, *c*) has a shallow concavity in one side and may have been a paint bowl. A similar specimen was found in the 1934 work. Neither indicates that it was a mortar in which pigment was ground. Both must have served merely as mixing bowls or palettes. One piece has a number of grooves or scratches in one side. These indicate that it was employed as a sharpening stone for touching up the ends of bone awls.

Many pieces of hematite were obtained from various places in the excavations. Some are very small, but others are sizeable nodules. The surfaces on all of them are smooth and striated from rubbing. One piece was shaped until it approximates a trapezoidal form. An attempt was obviously made to perforate it, as it was drilled on two sides, but the hole was not completed. The owner probably intended to suspend it on a thong either as a pendant or to prevent loss. Hematite was widely used by the later Indians both for the making of ornamental objects and as a source of paint. To judge from the numerous fragments in the present collection, Folsom man also found it a necessary component in his material culture complex.

IDENTIFICATION OF BONES AND MOLLUSKS

A number of animals, in addition to the bison, are represented by the bones found at the Lindenmeier site. As mentioned in the discussion of the bison pit, Dr. Gazin has identified the remains of that animal as a form of *Bison taylori,* one of the extinct species. The other bones were submitted to Dr. Remington Kellogg, assistant curator, division of mammals, United States National Museum, who made the following identifications:

Fox, *Vulpes velox.*
Wolf, *Canis nubilus.*
Rabbit, *Lepus townsendii campanius.*
Pronghorn (Rocky Mountain antelope), *Antilocapra americana.*

The fox, wolf, and rabbit were represented in the material obtained in 1934, but the antelope was a 1935 addition. The bison is the only extinct animal in the group. There has been no change in the others from the time of the Pleistocene; hence they throw no light on the problem of the age of the site.

The invertebrate material was submitted to Dr. Horace G. Richards, research associate, New Jersey State Museum. The specimens and his identifications were checked by Dr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia. Dr. Richards found nine species represented in the mollusks. They are:

Gastrocopta armifera Say.
Gastrocopta ashmuni Sterki.
Pupilla muscarum (Linne).
Pupoides inornatus Vanatta.
Pupilla sonorana Sterki.
Vertigo sp.
Valonia gracilicostata Reinh.
Succinea avara Say.
Zonitoides arborea Say.

Seven of these species live in the region today. Two of them are considerably north of their present northern limits. *Gastrocopta ashmuni* Sterki has its present northern limits at Grand Canyon, Ariz., and southern and central New Mexico. The other, *Pupilla sonorana* Sterki, has a present northern limit of Mora County, N. Mex. According to Dr. Richards, this northern occurrence of the two species may indicate a warmer climate at the time of the deposition of the fossils.[23]

---

[23] Letter from Dr. Richards to the writer, Dec. 14, 1935.

SUMMARY AND DISCUSSION

The 1935 investigations at the Lindenmeier site consisted of the digging of two large trenches through the area where objects attributable to Folsom man are found, of further excavations in the deep pit in the ravine bank where most of the specimens obtained during the preliminary investigations were dug, and of uncovering the remains of a group of bison at the location where Judge C. C. Coffin, A. L. Coffin, and Maj. Roy G. Coffin made their original discoveries. The collection obtained from the work contains some 750 specimens, large quantities of chipper's debris, and numerous bones from animals killed by the former occupants of the region. The artifacts comprise a series of tools and implements of which 11.3 percent are points, 32.8 scrapers, 5.6 gravers, 1.0 chisel-gravers, 0.5 choppers, 3.0 knives, 6.3 large blades, 0.8 hammerstones, 1.6 pieces of hematite which have been rubbed or shaped, 13.6 channel flakes from the longitudinal grooves in the faces of the typically fluted points, 4.0 sandstone rubbers, 0.5 pieces of bone showing evidences of workmanship, and 19 percent flakes showing signs of work but too nondescript in character to permit classification as types of implements. The artifacts as a group show that the lithic component in the local cultural pattern was primarily a flake industry, slightly less than 1.5 percent of the implements being of the core type.

The size range in the points in the collection raises a pertinent question, namely. On what type of weapon were they used? The general conception, based on knowledge of the Southwest and the Mexican area, has been that the bow and arrow was a late development in the New World and that older cultures employed a spear and spear thrower. Archeologists occupied with the Folsom problem have assumed that the fluted points, because of their size, were used in a shaft hurled from a spear thrower. Many of the smaller examples in the present group could easily have functioned as arrowheads and suggest that the early bison hunters may on occasion have used the bow. Definite conclusions should not be attempted solely on the evidence of stone points, but attention should be called to the fact that all of them are not necessarily of a size requiring a spear shaft.

Interesting evidence on one of the " burning issues " in the archeology of the western plains area, the Folsom-Yuma problem, was obtained from the investigations. Stratigraphic material demonstrated that as far as the Lindenmeier site is concerned there was only a very late contemporaneity between Folsom and Yuma points, the Yuma appearing toward the end of the Folsom occupation and surviving

longer. Furthermore, Yuma points constitute so small a factor that it is questionable whether they should be considered as belonging to the complex.

Five species of animals are represented in the bones from the site. Only one, the bison, is an extinct form. Nine species of mollusks were found and while none of these is extinct, two are considerably north of their present range. Their presence at the Lindenmeier site is considered an indication that the climate was somewhat warmer and moister when Folsom man was there than it is now.

The large trenches revealed in cross-section the deposits overlying the old level of occupation and demonstrated that what now constitutes a terrace was at one time an old valley bottom. The ridge that bordered its southern side has been eroded away since the area was abandoned by its aboriginal occupants. The nature of the valley fill, as exposed in the trench walls, suggests that the changes which culminated in the present state of the site could not have been extremely rapid ones. Considerable time must have elapsed since the layer containing the man-made objects was laid down. Evidence in the trenches also indicated that the makers of the tools and the Folsom points stopped for a time along the slope above the old valley bottom. If the trenches did not cross a portion of the real campsite, they at least bordered on it. This was shown by the finding of cut and burned bones, charcoal and wood ashes, hammerstones and chipper's debris, and implements broken in the making. All were so situated that their locations could not be attributed to drift or to the washing down of material from higher levels. The broken implements, when the fragments are fitted together and the original flake is restored, give good evidence of the technique used in the manufacture of tools.

The trenches did not produce data that are of aid in determining the age of the site. Despite their establishing the fact that the soil layer in which the objects are found was produced by the natural decay and break-up of the top of the Oligocene bed underlying the area, they gave no clue either to the agency that originally eroded away the overburden, thus laying bare the Tertiary stratum and forming the old valley, or to the time when the action took place. Conditions at the Clovis lake beds are somewhat better from the standpoint of dating, and Dr. Ernst Antevs has reached the conclusion, from extensive studies of the area, that the Folsom artifacts found there represent an antiquity of from 12,000 to 13,000 years.[24] Since the Clovis material indicates that it comprises the relics of a people whose material

[24] Antevs, 1935, p. 311.

culture was similar to that of the group occupying the Lindenmeier site, it may be suggested that the latter was approximately the same age. This should not be regarded as an established fact; it is merely a postulation based on analogy. Subsequent work may show the two sites to have been as widely separated in time as they are in space. There is still an opportunity to obtain a geologic date for the Lindenmeier site through a study of the terrace system of the South Platte River and the relation of its terraces to the glaciation in the Rocky Mountains to the west. The Lindenmeier terrace can be correlated with those of the South Platte, but as yet there has been no determination of the ages of the latter. An attempt to solve this particular problem will constitute a part of the program for future work in the region.

No human remains have been found, and so far as his physical characteristics are concerned, Folsom man is still a *persona incognita.* There is no evidence as to what type of shelter he may have used. On the other hand it seems obvious that he was a typical hunter depending entirely upon the bison for his maintenance and sustenance. He no doubt supplemented his preponderant meat diet with wild seeds and " greens " but did not cultivate his own vegetal food. He probably did not settle long in one place but traveled wherever the bison moved, in order to support himself. For that reason it is not likely that his dwelling consisted of anything more substantial than a tent made from the skins of that animal. Traces of the places where he pitched his shelter will be extremely hard to find at this late date. A hard packed floor and hearth, perhaps some post molds, is the most that can be expected. He probably tarried as long at the Lindenmeier camp as he did at any of his settlements, possibly longer than at most of them when its advantages are recalled. Hence the chances of locating a lodge site or even of uncovering his own remains are not altogether beyond the bounds of likelihood.

The old valley bottom with its numerous meadows, marshes, and bogs undoubtedly attracted bison because of the reeds and sedge grasses for feed and the mire in which to wallow. It is not likely that large herds frequented the district—rather that small groups drifted in from the plains to the east. The presence of the animals would draw Folsom man into the area, but in addition there were the assets of raw material for use in making implements, a good supply of water, firewood, and a pleasant camping spot. Here he could stalk his game, cut and dry the meat not wanted for immediate consumption, tan the skins, make his tents and such clothing as his needs required, fashion

his tools from the available stone, and prepare his equipment for the inevitable trek when the bison shifted to other pastures.

Present indications are that the Lindenmeier site was not occupied continuously by a large group of people. It probably was an annual summer and fall camping grounds visited regularly over a period of years by smaller parties. That the intervals between occupations were not protracted is shown by the homogeneous nature of the layer in which the artifacts are found.

LITERATURE CITED

Antevs, Ernst

1935. The occurrence of flints and extinct animals in pluvial deposits near Clovis, New Mexico, pt. 2, Age of the Clovis Lake clays. Proc. Acad. Nat. Sci. Philadelphia, vol. 77, pp. 304-312, Oct. 10.

Bolton, H. E.

1916. Spanish exploration in the Southwest, 1542-1706.

Castañeda, C. E., *tr.*

1935. History of Texas, 1673-1779, by Fray Juan Agustin Morfi. The Quivera Society, vol. 6, Albuquerque.

Catlin, George

1841. The manners, customs, and conditions of the North American Indians. London.

Cook, H. J.

1927. New geological and paleontological evidence bearing on the antiquity of mankind. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, no. 3, pp. 240-247, May.

Espinosa, Gilberto, *tr.*

1933. History of New Mexico, by Gaspar Pérez de Villagrá, Alcalá 1610. Introduction and notes by F. W. Hodge. The Quivira Society, vol. 4, Los Angeles.

Figgins, J. D.

1927. The antiquity of man in America. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, no. 3, pp. 229-239, May.

1933. The bison of the western area of the Mississippi Basin. Proc. Colorado Mus. Nat. Hist., vol. 12, no. 4, Dec. 5.

1934. Folsom and Yuma artifacts. Proc. Colorado Mus. Nat. Hist., vol. 13, no. 2, Dec. 29.

1935. Folsom and Yuma artifacts, pt. 2. Proc. Colorado Mus. Nat. Hist., vol. 14, no. 2, Oct. 3.

Hammond, G. P., and Rey, Agapito, *trs.*

1929. Expedition in New Mexico made by Antonio Espejo, 1582-1583, as revealed in the journal of Diego Pérez de Luxán, a member of the party. The Quivera Society, vol. 1, Los Angeles.

Hay, O. P., and Cook, H. J.

1930. Fossil vertebrates collected near, or in association with human artifacts at localities near Colorado, Texas; Frederick, Oklahoma, and Folsom, New Mexico. Proc. Colorado Mus. Nat. Hist., vol. 9, no. 2, Oct. 20.

Howard, E. B.
1935. Evidence of early man in North America. Mus. Journ., vol. 24, nos. 2-3, Univ. Pennsylvania Mus.

Renaud, E. B.
1931. Prehistoric flaked points from Colorado and neighboring districts. Proc. Colorado Mus. Nat. Hist., vol. 10, no. 2, March.
1932. Yuma and Folsom artifacts (new material). Proc. Colorado Mus. Nat. Hist., vol. 11, no. 2, November.
1934. The first thousand Yuma-Folsom artifacts. Univ. Denver Dep. Anthrop. October.

Roberts, F. H. H., Jr.
1935. A Folsom complex, preliminary report on investigations at the Lindenmeier site in northern Colorado. Smithsonian Misc. Coll., vol. 94, no. 4, June 20.

Winship, G. P.
1896. The Coronado expedition, 1540-1542. 14th Ann. Rep., Bur. Amer. Ethnol., pp. 329-598.

1. GENERAL VIEW OF SITE SHOWING RAVINE AND TRENCHES ACROSS TERRACE

2. LOWER END OF TRENCH A

Man standing on top of clay substratum.

1. SIFTING EARTH FROM SECTION AT LOWER END OF TRENCH A

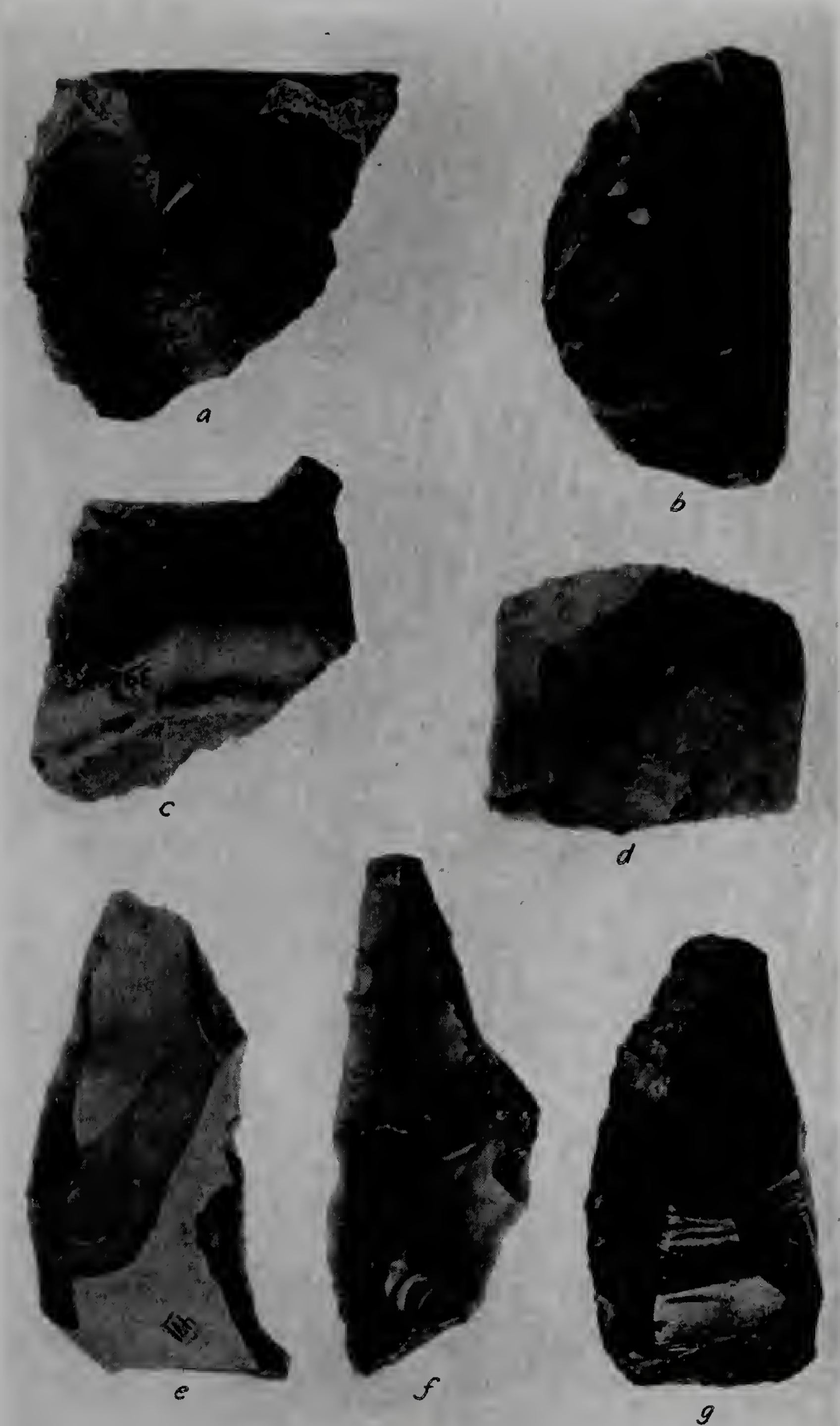
2. ARTIFACTS IN SITU

Chopper at left, portion of Folsom point at right.

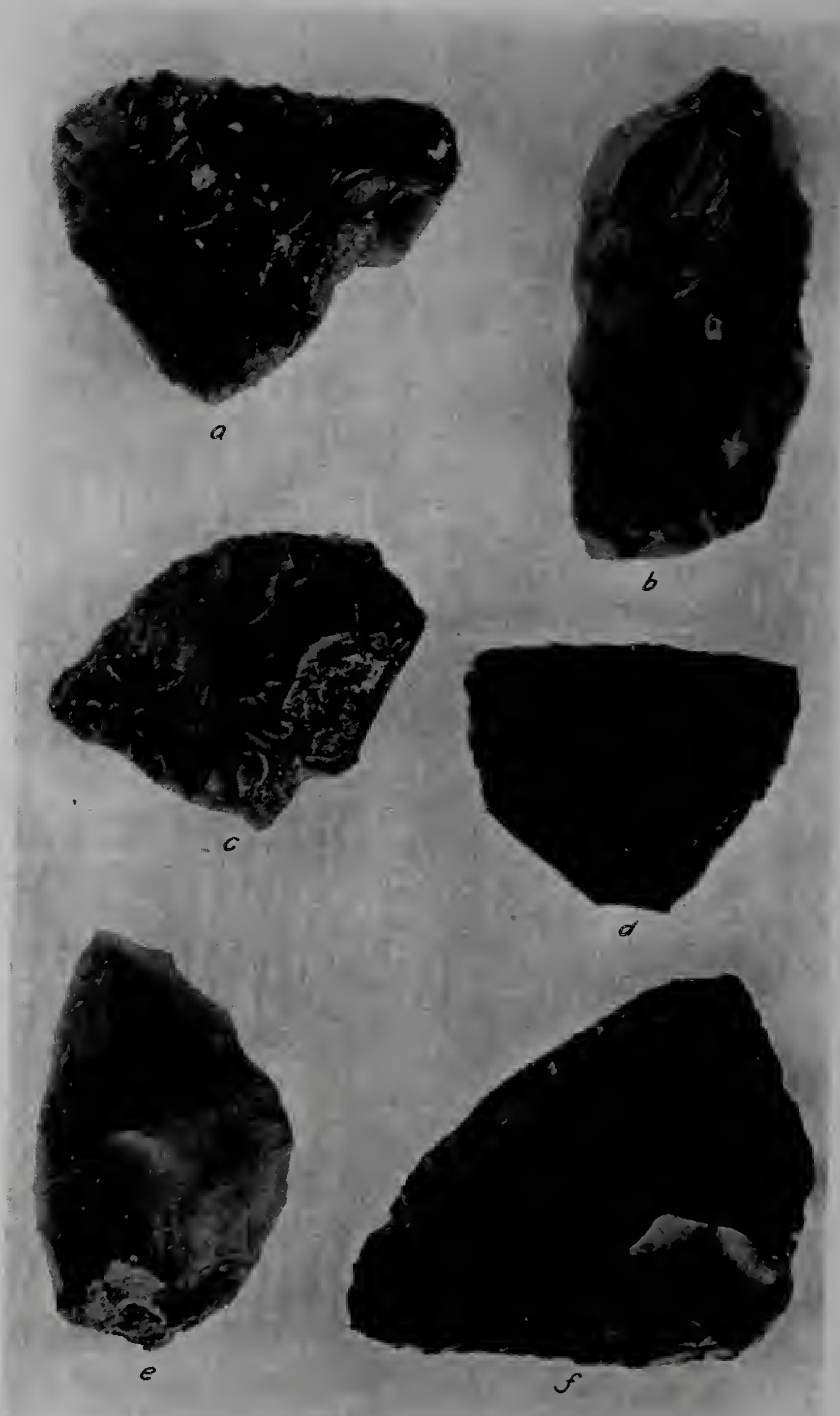
1. UNCOVERING ARTICULATED BISON LEG IN BISON PIT

2. VERTEBRA WITH POINT IN VERTEBRAL FORAMEN

FOLSOM POINTS
Actual size.



SIDE SCRAPERS
Actual size



SIDE SCRAPERS
Actual size.

LARGE QUARTZITE SCRAPERS
One-half size.

"Snub-Nosed" Scrapers
Actual size.

GRAVERS, CHISEL-GRAVERS, BONE DISK
Actual size.

FLAKEKNIVES
Actual size.

FLAKEKNIVES
Actual size.

RUBBING STONES, *A–E*; SCRAP NODULES, *F–H*; HAMMERSTONES, *I–J*

One-half size.

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1936

(Publication 3407)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1937

NEW DEVELOPMENTS IN THE PROBLEM OF THE FOLSOM COMPLEX

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

Investigations of the Folsom complex and its significance in the field of American archeology were continued during the summer of 1936. Most of the work centered at the Lindenmeier site in northern Colorado, but two other localities where the same type of remains have been found were also studied. One of these was in Iowa, the easternmost occurrence of true Folsom material thus far noted, and the other was near Kersey, Colo., some 50 miles southeast of the Lindenmeier site.

Several typically fluted projectile points of the Folsom type have been found along Kenyon Creek, Fremont County, in the extreme southwestern corner of Iowa. One of these points and a number of scrapers were washed out of the stream bank a few miles from the town of Anderson. The writer, accompanied by Christie H. Hein, who reported the finds, visited the site in June. The creek has cut down through the thick alluvial deposits characteristic of the region, and at the present time its bed is along the top of a hard, light-colored clay deposit which underlies the district (fig. 62). Along the top of this substratum, separating it from the upper levels, is a thin, dark soil line from which the artifacts probably came. Digging along the bank near the spot where the point was found produced some chert flakes similar to the stone in the point and scrapers, and some fossilized bison bones. In a large collection of objects from an old Indian village site nearby there is no material comparable to that from the creek bank. The position of the stone flakes and the bone fragments shows that they are considerably older than the village site. The area is a promising place for additional evidence on the Folsom problem.

The site near Kersey, Colo., was discovered in the early summer of 1935 by F. W. Powars and his son Wayne, residents of Greeley. The writer visited it twice during that season and in August 1936 did some digging there (fig. 63). The remains are located on a low terrace of the rolling terrain comprising the south side of the South Platte River valley. Available evidence indicates that it was a camp occupied for only a relatively short period of time, in comparison with the Lindenmeier site. That tools were made there is demonstrated by

FIG. 62.—Bed of Kenyon Creek. Man is standing where implements were found.

FIG. 63.—Starting work at Powars Site near Kersey, Colo.

FIG. 64.—Uncovering bone fragments near bison pit at the Lindenmeier Site.

FIG. 65.—Split bison bones in situ. Scale rod is 2 feet in length.

the number of implements broken in the process of manufacture and the quantity of chips and flakes scattered over the area. Specimens represent a typical Folsom complex and are so similar to those from the Lindenmeier site that in a mixed group it would be difficult to distinguish those from the two sites. Bones are scarce, and the few examples recovered are so fragmentary that they are of no value in determining the animals represented.

The Powars site presents a peculiar problem in that the objects occur either just below the surface or at a depth of from 1 foot to 18 inches. There are no traces of an actual occupation level. The possibility that the material is drift from higher slopes was investigated, but nothing was found to indicate that it could be attributed to such an occurrence. The probable explanation lies in the fact that the soil is sandy and easily swept away by wind. As a consequence the upper levels have disappeared. The stone objects were too heavy to be moved by such action and remained as "floats" on each new surface appearing subsequent to storms. When the field was plowed a few years ago they were turned under to the depth found. Recent tilling has tended to distribute them somewhat in the upper level. The digging of a test pit 6 feet deep failed to reveal anything below the maximum 18-inch level of disturbance. Hence it appears that the material is practically a surface deposit.

Excavations at the Lindenmeier site were restricted to three locations. One of the areas was adjacent to the pit where the remains from nine individual bison were found, and the other two were near the large trenches that constituted the major part of the preceding season's operations. The digging in the vicinity of the bison pit was for the purpose of obtaining additional bone material in the hope that other identifiable animals would be found (fig. 64). The results exceeded expectations as a number of foot bones from the camel, probably *Camelops,* were obtained in direct association with those from bison. This adds one more extinct species to the animals associated with Folsom material. The assemblage of bones at this place throws an interesting sidelight on one of the customs of the people, namely, that on occasion the animals were cut up and cooked at the scene of the kill. The hacked and split bones (fig. 65), as well as numerous stone implements, were found covering an area of 250 square feet. They were close to the place where the bison skeletons occurred, although on the windward side. There was evidence demonstrating that the carcasses of the animals had been dismembered and the meat cooked and devoured on the spot. There was no actual hearth, but the remaining charcoal and ashes showed that a sizable fire had burned there on the

Fig. 66.—General view across excavations near old trenches at Lindenmeier Site.

Fig. 67.—Cut bones and stone objects before removal.

surface. Many of the bones are charred, and several projectile points recovered from the debris exhibit the effects of fire, suggesting that they were in the meat when it was roasted. The excavations here also revealed the fact that the barbecue was held on the bank of a small stream which had flowed along the bottom of the old valley. There were no indications of this former physiographic feature until it was brought to light by the digging. An additional item of interest concerns the finding of the tip ends from two Yuma blades, a type of point present in the Plains area to the east which has been thought to have some affinity to the Folsom complex. Both of these specimens came from a much higher level than the Folsom implements, an indication that at this site they represent a considerably later date.

Work was undertaken alongside of the previous year's trenches because finds made in them suggested that they had bordered upon, if they did not actually cross, a portion of the camp site (fig. 66). An area measuring 15 by 30 feet was cleared at one place, and the overburden was removed from a surface of 625 square feet at another. There was ample evidence of occupation, although there were no traces of shelters or habitations, and remains of true fire pits were absent. At one place a pile of 656 stone flakes and one partially completed knife blade clearly indicated that an implement maker had been seated there busily engaged in the manufacture of tools. Other parts of the excavated area exhibited features similar to those described in connection with the feast at the bison pit. Here again were numbers of cut and split bones and the tools used in the process (fig. 67). In addition there were traces of surface fires, quantities of chipper's debris, and numerous broken and unfinished tools. The latter add materially to the information already obtained relating to the techniques employed in the making of implements. The specimens found here also include several new types of tools.

One of the most significant facts established by the 1936 excavations is that the site was occupied before, as well as during, the formation of the thick black-soil layer produced by heavy vegetation that thrived when conditions were more favorable than those of recent times. That the people were there prior to the inception of this extensive growth cycle points to an even greater antiquity than was evidenced by the presence of materials in the bottom of the soil profile. The full import of this feature can not be determined, however, until the completion of geologic studies of the deposits. The latter were started in 1935 by Dr. Kirk Bryan, of the Division of Geology, Harvard University, and were continued during the 1936 season, under Dr. Bryan's supervision, by Louis L. Ray.

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1937

(Publication 3480)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1938

THE LINDENMEIER SITE IN NORTHERN COLORADO CONTRIBUTES ADDITIONAL DATA ON THE FOLSOM COMPLEX

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology.

Investigations in a little-known phase of American archeology were continued during the summer of 1937 at the Lindenmeier Site in northern Colorado. It is at this location that Folsom man, one of the earliest known inhabitants of the New World, camped and left numerous examples of the weapons and tools that he manufactured and used in his occupation of killing big game. Excavations made in previous field seasons contributed much information on the material culture of the people and threw some light on their mode of life, but they produced no skeletal remains to show what manner of men they were. The 1937 work added valuable data on various phases of the problem, although it failed to locate any of the elusive individuals or to find even one human bone.

When the writer and members of the Bureau of American Ethnology-Smithsonian expedition returned to the Lindenmeier ranch in June, excavations were resumed at the place where they terminated at the end of the preceding season. During the course of the summer an area covering some 2,800 square feet was uncovered and numerous traces of occupation were found (fig. 117). The level where the remains occur follows an old hillside and its depth below the present surface ranges from 4 feet, where work began, to 6 feet 3 inches, the point reached when the season closed.

Specimens are found either at the bottom of an old soil zone or in a thin layer of earth, only slightly stained with humus, just below it. The underlying stratum over the entire area is a hard tufaceous clay dating from the Oligocene. In some places the dark soil stratum rests on this clay and the artifacts are along the contact. Where the thin stained earth layer intervenes, the objects are scattered through it. The importance of this occurrence is that it demonstrates the presence of the people in the region prior to the developments leading to the formation of the heavy soil zone, as well as during its initial stages. The thin layer was formed by the decay of the surface of the tufaceous layer, the deposition of some wind-borne material, and some decaying vegetal matter. Sections where it is absent con-

FIG. 117.—General view of portion of area being excavated.

FIG. 118.—Boulders used as anvils in left foreground of picture.

FIG. 119.—Workman uncovering cut and split animal bones.

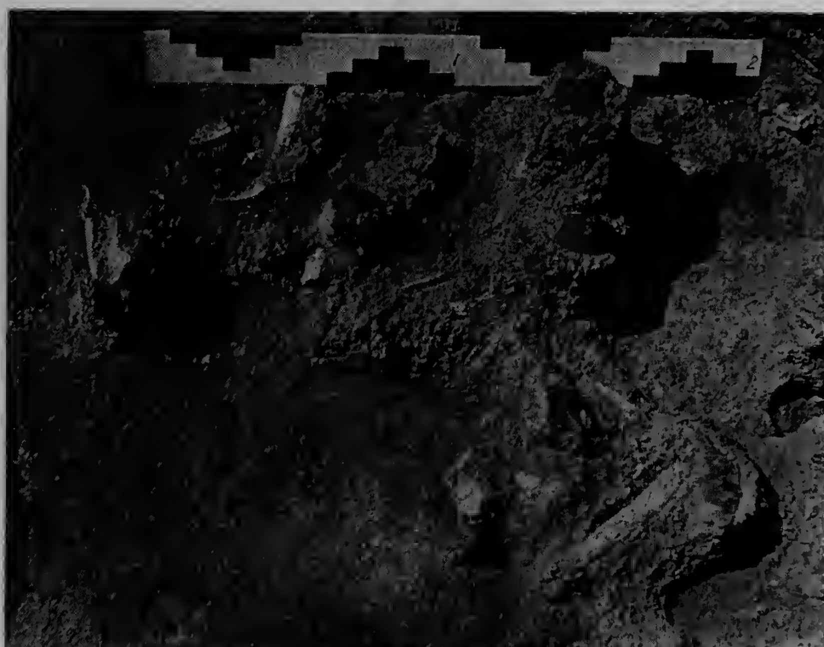


FIG. 120.—Stone implements and bone fragments in situ.

stitute high spots on the surface of the tufaceous layer that were exposed to wind and water action. The latter either prevented the formation of the thin layer or carried it away and permitted the heavy soil zone to develop on top of the clay substratum. The thicker, dark layer was produced by heavy vegetation, rank grasses, during an interval when there was considerably more moisture and more propitious growing conditions. This factor ties in with geologic studies of the site and surrounding area and is of significance from the standpoint of the age of the site.

A number of boulders were lying on what was once the old hillside (fig. 118). These stones were in the same positions that they had occupied when that level was the inhabited surface. Several showed that they were used for anvils. Bones, to be cracked and split for marrow, and stone nodules, sources of material from which to make tools, were placed on these boulders and struck with hand-held hammer stones. Innumerable splinters and small fragments of bones were in the dirt around some of them, while flakes and chips of chert, chalcedony, jasper, and other materials favored for implements lay alongside others. The status of the objects definitely indicated that they were just as left by the one-time dwellers at the site, that they were not washed there, and that this actually was a portion of the former camp.

Other parts of the excavated area yielded quantities of cut and split animal bones (fig. 119) associated with stone implements (fig. 120) and other evidences of human activity. The implements consist of typically fluted projectile points, scrapers of various kinds, knives, drills, and flakes with minute points that probably were used to scratch designs on bone and stone. Many of these artifacts are similar to those found in previous years, but a number represent new types. Several bone fragments bearing portions of incised decorations were also obtained.

Dr. Kirk Bryan and Louis L. Ray, of the Division of Geology, Harvard University, continued their geologic investigation of the site and neighboring regions and by the close of the season were able to formulate conclusions on the age of the deposits. The evidence indicates that the cultural layer was made long after the climax of the Wisconsin period and within the Late Glacial. Hence, it may be said that Folsom man lived in the region several thousands of years ago, while glaciers still lingered in the nearby mountains and the climate was colder and wetter than at present. The latter feature probably accounts, in part, for the heavy soil zone at the site.

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1938

(Publication 3525)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1939

ON THE TRAIL OF ANCIENT HUNTERS IN THE WESTERN UNITED STATES AND CANADA

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

Search for further information on Folsom Man, the aboriginal nomad who hunted big game on the western plains during the closing days of the Glacial Period, was continued throughout the summer of 1938. Excavations at the Lindenmeier site in northern Colorado, where previous investigations had revealed the remains of a camp once occupied by that early New World inhabitant, comprised a major part of the season's work. After the termination of the digging the writer visited sites in Nebraska, Wyoming, and Saskatchewan, Canada, where local collectors have found implements indicative of the Folsom or some presumably associated complex.

When the Bureau of American Ethnology-Smithsonian Institution Expedition had established camp at the Lindenmeier site (fig. 109), activities were resumed where the excavating was stopped at the end of the 1937 season and were continued until six additional parts of the area had been examined. Despite an unusually stormy summer (fig. 110), and the handicap of numerous heavy rains, some of cloudburst proportions, a total of 3,500 square feet of the original surface of occupation was uncovered. Removal of the overburden (fig. 111), ranging from 3 to 8 feet in depth, exposed various concentrations of stone implements, cut and split animal bones (figs. 112, 113, 114), the remains of several hearths, and places where stone chippers had fashioned different kinds of tools from nodules gathered from the surrounding countryside. The collection of specimens obtained includes several new types of knives and scrapers in addition to typically fluted points and other implements similar to those found in former years. There is also a series of bone fragments bearing incised lines, indicating that the people had a simple form of geometric art, and there are bits of polished bone suggesting that tools were made from that substance as well as from stone.

The hearths were not well-made fire pits. They were either simple depressions in the earth or merely places where fires had been kindled on the surface. Most of the animal bones are from bison, the extinct *taylori*, although there are some from deer and antelope of as yet undetermined species and from smaller mammals such as the fox

FIG. 109.—Expedition camp at the Lindenmeier Site. (Photograph by Charles R. Scoggin.)

FIG. 110.—Electrical storms were frequent during summer of 1938. This picture was taken at 11:30 P. M. (Photograph by Charles R. Scoggin.)

FIG. 111.—The overburden being removed, layer by layer, from sections containing bone deposits. (Photograph by Charles R. Scoggin.)

FIG. 112.—Plotting and photographing bones and stone implements before their removal. (Photograph by Charles R. Scoggin.)

and jackrabbit. At some distance from the main diggings a portion of a mammoth tusk, together with some small splinters from split bones and some pieces of charcoal, was found in the same horizon as the other material. There were no implements or stone flakes in association with the tusk, and as a consequence it cannot be stated definitely that the creature was killed by the people who hunted the bison and other animals. There was nothing to indicate that the tusk and bone splinters were rolled or washed into the location where they were found. The edges are sharp and show no marks of abrasion. Evidence from other places has demonstrated that Folsom Man preyed on the mammoth, and it is possible that the dwellers at the Lindenmeier camp did likewise. The tusk at least shows that mammoth were in the vicinity at approximately the same time as the Folsom men, an occurrence previously suspected but for which there was no proof. One of the main objectives of the expedition, the recovery of a human skeleton, was not attained. Thus far not one bone attributable to man has come from the excavations, and the physical characteristics of the people are still unknown.

The sites visited in Nebraska are located in the southwestern corner of the State in Chase and Dundy Counties. All those seen by the writer are "blow-outs," places where constant action by strong winds has swept away areas of surface soil exposing the underlying stratum of harder, claylike earth. The artifacts—points, scrapers, knives—are found lying on these exposed surfaces. Folsom type points occurring there are quite like those from the Lindenmeier site. In addition there are numerous long, narrow, thick-bodied points with a triangular or oval cross-section that have been given the name Yuma. The latter are a complicating factor in that their meaning is not clear. They may belong to the Folsom series or be an indication of another complex. They are found in association with Folsom material in some localities, but in others they are not. Only a very small percent of the points from the Lindenmeier site can be regarded as having Yuma characteristics, and the majority of these come from higher levels. Hence for that district they can be regarded, at most, as demonstrating a very late contemporaneity between the two forms. Information from the Nebraska sites contributes little toward answering the relationship question because no digging was done.

On the strength of information from D. B. Hilton, of Sundance, Wyo., the writer went to that place to investigate the finding of two Yuma type points and a series of five bison skulls. The discoveries came as the result of work on an earth dam across Sundance Creek just east of the town. The points were at the bottom of the soil zone

FIG. 113.—Chopped and split bones in place before removal. Measuring stick is 2 feet long. (Photograph by author.)

FIG. 114.—Bones and stone tools in situ. Small numbers indicate location of implements. (Photograph by author.)

that forms the present floor of the valley. When first seen they were protruding from the bank of the stream 2 feet below the present surface and several feet above the water line (fig. 115). They were just above a bed of hard red clay that forms the substratum for the area. The bison skulls were scooped out by a grader gathering dirt to be used on the dam. They were together, forming a single group, and no other bones accompanied them. They came from the same horizon as the points, and although conclusions cannot be formed from material not actually in situ, it seems reasonably certain that they belong to the same period of deposition as that represented by the points. The skulls are definitely those of modern buffalo. Numerous flakes and chips of stone, pieces of charcoal, and traces of ashes occur at the same level. These suggest a surface of occupation and the possibility of the remains of a camp nearby.

There are several places in the vicinity of Sundance where stone artifacts are found on the surface, and many local residents have sizeable collections gathered from them. All of these were seen and studied and a dozen more Yuma points, either complete or represented by easily identifiable fragments, noted. There were no points or fragments of the Folsom type. The collections also contain many examples of the barbed arrowheads so widely used by the Plains Indians, as well as knives and scrapers, none of which exhibit characteristics of the Folsom tools of similar form and purpose. One group of points from a single location on a hillside a short distance from Sundance is of particular interest because all are of the same type as an example obtained from a stratum lying 2 feet above the Folsom layer at the Lindenmeier site. They apparently are older than the ubiquitous barbed arrowhead, but are much later than Folsom. Their occurrence with Yuma specimens indicates that in the Sundance area, at least, there was a much later survival for the Yuma than for the Folsom.

In the vicinity of Mortlach, Saskatchewan, are a number of "blow-outs" that developed as a concomitant of the droughts and high winds prevailing there in recent years. They are much like the "blow-outs" in the plains districts farther south in the United States. At various places the completely dried out top soil has been swept from the surfaces of fields, exposing a hard, grayish-black, sandy-clay deposit. Animal bones and stone implements are weathering out of this substratum (fig. 116), and large collections of points and other tools have been gathered by local people interested in Indian artifacts. The existence of these sites was called to the writer's attention in the autumn of 1937 by Kenneth F. Jones, of Mortlach. Letters and pictures sent by Mr. Jones indicated that he had found portions of Folsom points,

FIG. 115.—Bank where Yuma points were found near Sundance, Wyo. Location was at left of standing figure. (Photograph by author.)

FIG. 116.—Exposed surface in "blowout" near Mortlach, Saskatchewan. Light spots in foreground in front of standing figure are bones weathering out of the sandy-clay. (Photograph by author.)

numerous examples of the Yuma, and other implements suggestive of an older horizon than that of the recent Indians.

Mr. Jones took the writer to the places where he obtained the various specimens comprising his extensive collection. Most of them lie to the north of Mortlach, but some are to the west and the south. The district is typically plains land, mainly flat, although there is some slightly rolling terrain. The area north of the town, where the best artifacts occur, suggests the former existence of a series of shallow lakes or ponds, marshes, and bogs extending in a northwest to southeast direction. These no doubt attracted game animals and their shores would provide good camping places for the people hunting them, which probably accounts for the presence of the extensive remains of both. Most of the bones scattered over the surface and weathering out of the bottoms of the "blow-out" basins appear to be from bison, although other smaller forms are present. Many of the bison bones correspond in size to those from modern buffalo and may represent that animal. Others are larger and may possibly be from one of the extinct forms. To settle this question, it would be necessary to obtain by excavation those portions of skeletons on which species identification is based. Only a few points and fragments of Folsom type, five or six at most, have been found in this region, but there are literally hundreds of the Yuma and barbed forms. Most of the specimens have been picked up from the surface, but a few have been scratched out of the top of the exposed substratum.

The constant association between Yuma and barbed types should not be stressed too strongly at this time; the latter could have been in higher levels and dropped down to the top of the hard layer as the overlying soil was blown away. Yet the writer dug one barbed example from the substratum and found another partially embedded in it. On the other hand, many Yuma pieces lying loose on the surface have been picked up by collectors. In view of this, coupled with the indications at Sundance, it seems that a somewhat later horizon is indicated than is the case where points are predominantly of the Folsom type. The Mortlach sites are important, however, because of their size and the amount of material present in them and because there is the possibility of finding places along the edges of the "blow-outs" where excavation would reveal stratified deposits and produce evidence on the sequence of the different forms of implements. They extend the range of Folsom and Yuma artifacts well toward the north along the supposed avenue of migration for peoples coming over from Asia, and investigations in the Mortlach district may furnish much needed data on the Yuma problem.

ANNUAL REPORT OF THE BOARD OF REGENTS OF

THE SMITHSONIAN INSTITUTION

SHOWING THE

OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR ENDED JUNE 30

1938

(Publication 3491)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1939

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - Price $1.50 (cloth cover)

THE FOLSOM PROBLEM IN AMERICAN ARCHEOLOGY [1]

By Frank H. H. Roberts, Jr.
Archeologist, Bureau of American Ethnology

[With 15 plates]

The so-called Folsom problem has assumed an important place in American archeology during the last decade. It is outstanding in popular interest, and in scientific circles it is regarded as significant. This is due to the fact that it is closely coupled to the question of early man in the New World. At several places in New Mexico and Colorado implements have been found in association with bones of extinct animals and in deposits suggestive of geologic antiquity. These discoveries help push the date of occupation farther back into the past and have encouraged renewed consideration of the length of time that man has been in America. The more important sites where such finds have been made are those near Folsom, between Clovis and Portales, and in the Guadalupe Mountains in New Mexico; and at the Lindenmeier ranch and Dent in Colorado (fig. 1).

The first in the series—that which gave its name to archeological remains of the type—is on a small intermittent tributary of the Cimarron River, in a little valley named Dead Horse Gulch, several miles west of Folsom, Union County, N. Mex. It lies below the eastern rim of Johnson Mesa and was discovered in the summer of 1925 by local residents. Fred J. Howarth and Carl Schwachheim of Raton, N. Mex., reported the find to J. D. Figgins, then director of the Colorado Museum of Natural History at Denver, now director of the Isaac W. Bernheim Foundation, Louisville, Ky. Bones sent to the museum showed that the remains were those of an extinct species of bison and of a large deerlike member of the Cervidae. Prospects for fossil material were so promising that the Colorado museum sent a party to the site in the summer of 1926. Bearing in mind an occurrence 2 years previous when another group from the museum was digging near Colorado, Tex., and uncovered two chipped-stone objects in

[1] Reprinted, by permission, with some revision, the addition of new information, illustrations, and references, from Early Man, as depicted by leading authorities at the International Symposium, the Academy of Natural Sciences, Philadelphia, March 1937. J. B. Lippincott Co., 1937.

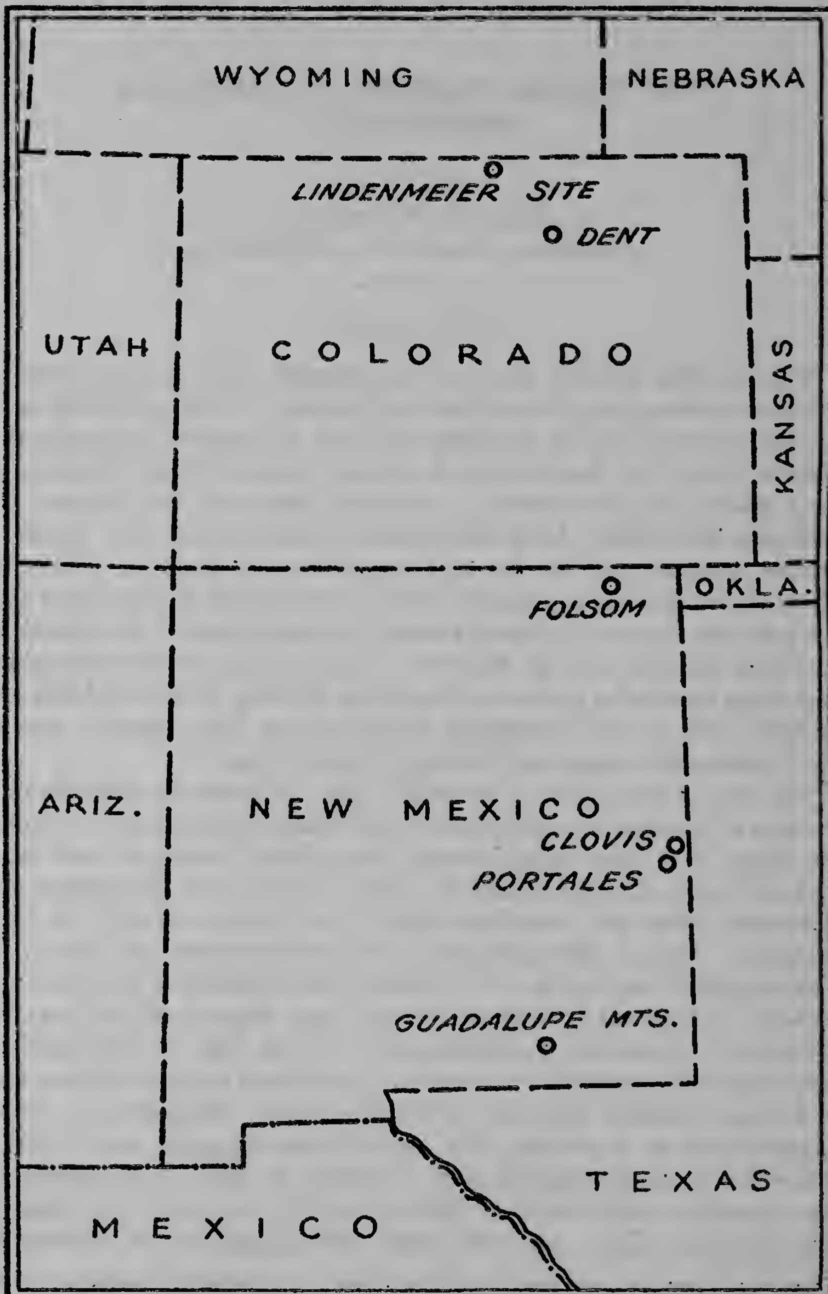


FIGURE 1.—Locations of principal Folsom sites.

association with an extinct bison, but failed to preserve their evidence in acceptable form, Mr. Figgins gave explicit instructions for the workmen to watch carefully for such artifacts at the Folsom pit. Parts of two finely chipped projectile points were recovered from the loose dirt during the excavations (pl. 1, fig. 1, *a*, *b*, *c*). Near the place where one of them was picked up, a small triangular piece of stone was found embedded in the clay surrounding an animal bone. This fragment was left in the block of earth and sent to the laboratory at Denver. When the dirt was carefully cleaned away from the stone it was noted that it was of the same material as one of the points. Close examination showed that it was actually a part of the point as the two pieces fitted together (pl. 1, fig. 2). This indicated a definite association between man-made objects and an extinct bison. Mr. Figgins was greatly impressed by the find and reported it to a number of archeologists and general anthropologists. The information was skeptically received in most quarters, and in several instances there was a definitely hostile attitude toward suggestions that the occurrence might be of importance and worthy of further investigation.

The Colorado Museum again sent a party to Folsom in the summer of 1927 and had the good fortune to find additional points. One of these was noted before it was completely uncovered, and work was stopped. Telegrams were sent to various institutions inviting them to send representatives to view the point in situ. Dr. Barnum Brown, of the American Museum of Natural History, New York, and the writer responded. Arriving at the quarry (pl. 2, fig. 1), he found Director Figgins, several members of the Colorado Museum board, and Dr. Brown. The latter had just uncovered the point which became the pattern and furnished the name for the type. There was no question but that here was important evidence. The point was still embedded in the matrix between two bison ribs (pl. 2, fig. 2). In fact, it has never been removed from the block, which is now on exhibit in the Colorado Museum of Natural History at Denver. The writer returned to Raton and telegraphed Dr. A. V. Kidder, then associated with Phillips Academy, Andover, now with the Carnegie Institution of Washington, and urged that he also visit the site. Dr. Kidder, who was engaged in excavations at Pecos, N. Mex., arrived 2 days later. After the whole situation had been studied carefully, it was agreed that the association could not be questioned nor explained away by any of the customary arguments against the authenticity of such an occurrence. That winter Dr. Brown, Dr. Kidder, and the writer reported on the finds at the annual meeting of the American Anthropological Association at Andover, Mass. In spite of the convincing nature of the evidence, most of the anthropologists continued to doubt the validity of the discovery.

The American Museum of Natural History and the Colorado Museum cooperated at the site in 1928. Dr. Barnum Brown headed the expedition, taking charge of the actual excavations, and several graduate students in anthropology under the supervision of Dr. Clark Wissler, head curator of anthropology at the American Museum, assisted by making a survey of the surrounding area in search of caves, rock shelters, or camp sites where the makers of the points might have lived. The survey had negative results, but the diggers were more fortunate. Additional bison skeletons were found with accompanying points, and numerous specialists—archeologists, paleontologists, and geologists—went to check the evidence. Consensus was that the finds were a reliable indication that man was present in the Southwest at an earlier period than formerly supposed and that they constituted one of the most important contributions yet made to American archeology. Most of the critics of previous years became enthusiastic converts and endorsed the Folsom materials. While the finds and their establishment as authentic were significant, of even greater consequence was the fact that Folsom paved the way to more considerate and unbiased studies of other discoveries indicative of an earlier New World occupancy and made it possible for those interested in that subject to continue their investigations without inviting the stigma of charlatanry. An ever increasing tendency to condemn arbitrarily any occurrence even slightly suggestive of antiquity gave way to the more reasonable attitude of letting the facts decide the case.

The points associated with the bison bones differed from the ordinary types scattered over that portion of the Southwest. They are leaf-shaped blades characterized by a longitudinal fluting on each face. One of the examples found in 1926 (pl. 1, fig. 1, *a*, *b*), at first glance appears to have a channel on one side only, but that is due to the fact that the basal portion is missing and that the break occurred just above the end of the groove. This feature is apparent when the photograph (pl. 1, fig. 1, *b*), is examined closely. In addition to the channels, the points have a secondary chipping along the edges that bespeaks a highly developed stone-flaking technique. Owing to the proximity of the site to the town of Folsom, these points were generally referred to as Folsom points, and later were definitely so named by Mr. Figgins. Because the site represented the scene of a kill rather than a camp, other artifacts were scarce, a portion of a nondescript flake knife and a generalized type of scraper being the only additional forms; hence, for a time the point was the only implement recognized as Folsom.

The layer of bones and implements at Folsom were in a deposit of dark clay containing lenses of gravel and small concretions of lime. This alluvial stratum probably represents an old bog or water hole that was the principal reason for the presence of the animals. At the

conclusion of his work Dr. Brown emphasized the fact that the sediments overlying the bone bed were highly restratified earth of a nature indicating great antiquity. He concluded that they belonged to the close of the Pleistocene and placed the age of the remains at the end of that period. Some of the experts support this opinion. Others believe that the site should be considered Early Recent rather than Late Pleistocene, and there the matter rests today.[2]

The second important New Mexican area contains several sites. It lies approximately 160 miles southeast of Folsom, between Clovis and Portales, not far from the Texas-New Mexico boundary (fig. 1). The sites were reported to Dr. Edgar B. Howard of Philadelphia in the summer of 1932 by A. W. Anderson and George Roberts, of Clovis. Dr. Howard visited the area at that time and returned again in November of the same year, when a road-construction company, digging for gravel, exposed a layer of bluish clay containing quantities of animal bones and indications of human occupation. As a result of that inspection he planned a series of investigations for the summer of 1933. This began as a joint undertaking of the Academy of Natural Sciences and the University of Pennsylvania Museum. Later in the season Dr. John C. Merriam, president of the Carnegie Institution of Washington, visited the excavations and became so enthused over the prospects that he arranged for the California Institute of Technology to send a party, under Dr. Chester Stock, to cooperate in the work. Dr. Howard returned in the summer of 1934 in company with Dr. Ernst Antevs who studied the physiography of the region in an endeavor to date the sites. Dr. Howard again led a party to the Clovis sector in the summer of 1936. This was a joint project of the Academy of Natural Sciences and the Carnegie Institution of Washington. The work was continued in 1937 under the auspices of the University of Pennsylvania Museum and the Academy of Natural Sciences, with Dr. Howard acting in a supervisory capacity and John L. Cotter in direct charge of the excavations.

The Clovis-Portales area is part of the Staked Plains, the old Llano Estacado of the Spanish explorers. In this district the flatness of the terrain is broken only by sand dunes rising along the edges of shallow depressions. These dry basins occur in a series that extends in a general east-southeasterly direction about midway between Clovis and Portales. Evidence points to a former period of heavy precipitation. At that time the basins were more or less permanently filled with water. Subsequent desiccation reduced them to mere water holes. They eventually dried up entirely and were filled with drift sand. Recent wind and water action have left them in varying stages of erosion. The sand has been whipped up into dunes along

[2] For more detailed information on the Folsom site, see Brown, 1929; Bryan, 1937; Cook, 1927; Figgins, 1927; Roberts, 1935.

the northeastern borders of many of them, exposing a hard bluish-gray deposit. These constitute what are known locally as "blow-outs" (pl. 3, figs. 1 and 2). In some the bluish layer has been cut down to a harder, underlying stratum of caliche, leaving shelves or benches around the edges of the basins and "erosion islands" scattered through the middle. Excavations in these shelves and islands yield animal bones, stone artifacts, some bone tools, charcoal, and ashes. Many of the bones show the effects of fire, and a large number appear to have been cut and split for the marrow. In numerous cases there is a definite association between the bones and man-made objects. The bones represent an extinct species of bison and the mammoth (pl. 4, fig. 1). Hence, there is little question but that in this region man was contemporary with both animals. Camel and horse bones are present in lower levels antedating the human period of occupancy.

Implements found there comprise projectile points, various kinds of scrapers, rough-flake knives, knives, blades, gravers, bone tools of unidentified function and two sharpened bones that may have served as spear points. Some of the stone projectile points are significant because they are comparable to the fluted examples from the original Folsom quarry. Others do not have as pronounced channels, and some do not have the feature at all. The latter correspond to a much disputed form called the Yuma. The presence of the fluted forms is an indication of some cultural relationship between the makers of these implements and those from the Folsom pit. The meaning of the so-called Yuma specimens is not clear. They may belong to the Folsom implement complex, but it is possible that they represent trade objects or an influence from another complex. This is still to be determined. One theoretical study based on typology, without any actual stratigraphic evidence, derives the Folsom type from the Yuma. The validity of this hypothesis is made questionable, however, by the fact that in some localities Folsom materials are found without any associated Yuma points and in others the Yumas occur and the Folsoms are absent. Furthermore, numerous channel flakes and unfinished Folsom points show that the chipping technique was not the same as that employed on the Yuma specimens (pl. 4, fig. 2). The specimens from the Clovis-Portales sites demonstrate that the fluted points belong to a definite complex and that they are only one of a series of different types of implements rather than the major item in the material culture of a hunting people as the evidence from the original Folsom pit would tend to indicate.

General interpretation of the geologic evidence is that the blue-gray stratum in the Clovis-Portales region was a lake deposit, probably laid down when temperatures were lower and there was much more precipitation. These conditions have led Dr. Antevs to conclude that the time represented corresponds to the end of the Pleistocene period,

his pluvial stage, dating back 12,000 to 13,000 years in this particular district. A more recent study suggests that the horizon from which the artifacts come is the flood-plain bottom land of a Pleistocene river rather than a lake deposit and that the age is much greater than that indicated by Antevs.[3]

At Burnet cave in the Guadalupe Mountains, southeastern New Mexico, Dr. Howard found a fluted point in association with bones from an extinct bison and an extinct muskox-like bovid. The point differs in some respects from the typical Folsom form, despite the channels, and falls in the category of Folsom-like or Folsomoid, terms used by some investigators to indicate a variation in the fluted forms. The point probably belongs to the basic Folsom type, however, and for that reason has a bearing on the general problem. The association of point and bones in itself is indicative of some antiquity, but there is further significance in the fact that it occurred in a stratum underlying Basket Maker material. The Basket Makers represent the oldest definitely established horizon in the culture-pattern sequence of the Pueblo area in the Southwest and date back some 2,000 years. There is some question as to whether or not the peripheral Basket Maker material found in the Guadalupes and the Big Bend region farther to the southeast is actually as old as that from the main Basket Maker center, but the point and the bones unquestionably are of considerable age as they were in a hearth 4 feet below the bottom of the Basket Maker level.[4]

The Lindenmeier site is 28 miles north of Fort Collins, Colo., 1½ miles south of the Wyoming line (pl. 5, figs. 1 and 2). It was discovered in 1924 by A. L. Coffin, his father Judge C. C. Coffin, and C. K. Collins, all residents of Fort Collins. During the decade 1924 to 1934 the judge, his son, and a brother of the judge, Maj. Roy G. Coffin, of Colorado State College, visited it intermittently and collected specimens. From the beginning of their finds they recognized that the points were different from the ordinary arrowheads so abundant in the region but were not aware of their true significance until 1931 when they learned that they were Folsom type. Most of their material was gathered from the surface. A few implements and some bone scraps were scratched out of the soil, but there was no attempt at extensive digging. The site was brought to the attention of the Bureau of American Ethnology, Smithsonian Institution, by Major Coffin in the summer of 1934. As a result of a series of letters from the Major, the writer went to Fort Collins in September. The owner of the land, William Lindenmeier, Jr., gave permission for a series of investigations, and preliminary prospecting was started. This first

[3] For detailed studies of the Clovis-Portales sites, see Antevs, 1935a; Bryan, F., 1938; Cotter, 1937, 1938; Howard, 1935; Stock and Bode, 1936.

[4] Howard, 1935a, pp. 62-79.

work was continued through October and into November. Most of the digging was confined to a deep pit in an arroyo bank, where there was an exposed layer containing bones and artifacts (pl. 6, fig. 1), although some excavations were made at other portions of the site in an effort to determine its extent.

In 1935 two large trenches were dug across the portion of the site lying south of the deep pit in the ravine (pl. 6, fig. 2). This was done to reveal a complete cross-section of the deposits overlying the specimen-bearing stratum and to determine the source of the objects found in the deep pit (pl. 7, figs. 1 and 2). Trenches were also dug through a portion of the area near the location of the original Coffin finds. A bone pile comprising remains from nine individual bison, *Bison taylori*, the same species found at Folsom, was uncovered (pl. 8, fig. 1). Further work carried on at this location in 1936 revealed the remains of a feast or barbecue. The carcasses of the animals, those found the previous year and others included in the new material, had been dismembered and cooked at the scene of the kill. Many bones were charred and several projectile points recovered from the debris exhibit the effects of fire. In addition, numerous implements of various kinds were associated with the bones. Any lingering doubts concerning the contemporaneity of the makers of Folsom points and the extinct bison were dispelled when the tip end of a point was found in situ in the channel for the spinal cord in one of a series of articulated vertebrae (pl. 8, fig. 2). Further interest was added by the fact that several foot bones from a camel, probably *Camelops*, were in the assemblage. Excavations made near the previous year's trenches yielded ample evidence of human occupation. There were traces of surface fires, quantities of debris left by the makers when they chipped the implements, and numerous broken and unfinished tools. In the summer of 1937 work was continued from the place where the 1936 activities were stopped and further confirmatory evidence obtained. Additional pits were sunk at new portions of the site during the 1938 season and several areas where fires had been built, animals cut up and cooked, and implements made were revealed (pl. 9, figs. 1 and 2). Most of the bones belong to *Bison taylori*, but a few represent an as yet unidentified deer and a group of small mammals. At some distance from the excavations, yet within the boundaries of the site, a section of mammoth tusk associated with some cut and split bones and charcoal came to light. There were no points or implements associated with these remains, however, hence it cannot be stated definitely that they are contemporaneous with the other materials. The horizon in which they lay was identical with that where most of the excavations have been made, and as other sites have shown that Folsom hunters did kill the mammoth, there seems little doubt that such was the case at the Lindenmeier ranch.

During the summer of 1935 the Colorado Museum of Natural History also conducted excavations at the Lindenmeier site. These consisted of a series of 15 test pits spaced at intervals across the site, approximately at right angles to the line of the main trenches of the Smithsonian party. One of these test holes west of the large trenches penetrated the artifact-bearing stratum where there was a concentration of material. With this as a starting point an area 30 by 30 feet was excavated. This pit yielded most of the specimens obtained by the Denver group. The material thus collected adds to the general fund of information on the site. Mr. Figgins and John L. Cotter, who was in direct charge of the work, made available to the present writer, for study, all of the specimens obtained from their excavations, and Mr. Cotter also furnished a copy of the manuscript that he submitted as a report on the investigations.

Since the fall of 1934 Major Coffin and Judge Coffin, with the assistance of various friends, have carried on a series of independent explorations at different places on the site and have obtained a large number of artifacts to supplement the series collected by the other excavators.

Approximately 6,000 stone implements and a few ornaments, several of carved bone (pl. 10), as well as portions of tools made from animal bones have come from the digging. No human skeletal remains have been found, and no indications of a shelter or habitation have been observed. The general complex of implements consists of characteristically fluted points (pl. 11), snub-nosed scrapers (pl. 12), side scrapers (pl. 13), end scrapers, a variety of cutting edges, drills, flakes with small, sharp points that may have served to mark on bone, rough-flake knives, fluted knives, large blades, sandstone shaft polishers and rubbing stones of the same material. The few bone tools probably represent punches or awls. Most of the stone artifacts are chipped or flaked—there are no polished tools— and show that the lithic component in the material culture was primarily a flake industry, although tools of the core type are found. The latter are mainly hammers and choppers.

Evidence from the digging shows that the occupation level was once an old valley bottom which subsequently was filled in by the wearing away of bordering ridges. At the present time it suggests a terrace above an intermittent tributary to a series of streams that eventually join the South Platte River (pl. 5, fig. 1). This effect has been produced by erosion of the ridges that once bordered the valley on the south. At the time of occupation the valley bottom was dotted with bogs and marshy places. The makers of the implements camped on the slopes above these meadows. During the latter part of their occupancy and for some time subsequent to it climatic conditions were more favorable to vegetation than they

have been in recent times. This is demonstrated by the heavy zone of black soil that occurs in the lower levels of the deposits over most of the site. The artifacts and bones are found just below or in the bottom of this layer (pl. 14, figs. 1 and 2). In this respect there is similarity between the Lindenmeier and other sites where the materials were also present in dark-clay deposits, but in contrast to the others the Lindenmeier stratum does not represent alluvial deposits: it was produced by heavy vegetation. After the abandonment of the location by its human inhabitants an era of erosion set in, and material from the valley walls was washed down across the site. The fill in the valley bottom shows that there have been several alternating periods of erosion and building up between that time and the present (pl. 7, fig. 2). These changes were probably induced by the lowering of the water table resulting from the encroachment of small streams working headward from the south and from a progressive lessening of general precipitation over the area. Dr. Kirk Bryan and Dr. Louis L. Ray, of the Division of Geology, Harvard University, spent four seasons working on the geology of the region in an effort to date the period of occupation. They attacked the problem from the angle of determining the relation of the Lindenmeier Valley to the various terraces of the major drainage streams of the area. This correlation was established after many months of careful survey, and, by the same process of tracing terraces along the main streams back into the mountains, relationship with the various glacial stages was demonstrated. The conclusion reached is that Folsom men lived at the Lindenmeier site while glaciers still lingered in the mountains and when the climate was wetter and colder than now. Although the stage represented is long after the climax of the Wisconsin glaciation, it is still within the Late Glacial and is good evidence for the presence of men in the New World in Late Pleistocene times. From present knowledge it is not possible to give a close estimate of the number of years involved, but the age has been placed at from 10,000 to 25,000 years ago with the probability that it is closer to 25,000.

Present indications are that the Lindenmeier site was not occupied continuously by a large group of people. It probably was an annual summer and fall camping ground visited regularly over a period of years by smaller parties. That the intervals between occupations were not protracted is shown by the homogeneous nature of the layer in which the artifacts are found.[5]

The find at Dent, Colo., which lies some 50 miles southeast from the Lindenmeier site, consisted of mammoth skeletons and two large fluted points. This association is in agreement with that found by

[5] Further information on the Lindenmeier site is contained in Bryan, Kirk, 1937; Coffin, R. G., 1937; Roberts, 1935, 1936.

Howard and Cotter in the Clovis-Portales area and indicates that the finding of a portion of a tusk at the Lindenmeier site was not necessarily due to entirely fortuitous circumstances. The digging at Dent was started by Father Conrad Bilgery, S. J., and a number of his students from Regis College, Denver, and was completed by a party from the Colorado Museum of Natural History.[6]

Other sites where implements of the Folsom type are found are located in this same general area. One is near the town of Kersey, Colo., about 7 miles east from Greeley, Colo. It was discovered by F. L. Powars and his son Wayne, of Greeley, and the writer did some work there in the summer of 1936. The other is 18 miles northwest from Fort Collins, about 12 miles southwest from the Lindenmeier, and was found in the fall of 1935 by T. Russell Johnson, of La Porte, Colo. Some digging was done there in the summer of 1936 by Miss Marie Wormington of the Colorado Museum of Natural History. Neither of these two sites is as productive or extensive as the Lindenmeier, but the objects found there are in close agreement with those from the latter.

From the evidence now at hand certain broad generalizations may be made concerning the Folsom problem. No human remains definitely attributable to that phase of American archeology have been found. One skeleton from the Clovis-Portales region was reported as a Folsom man, but there were no accompanying artifacts to show that such was the case. Another purporting to be Folsom came from a bank of the Cimarron River 8 miles east of Folsom. It also had no associated objects that would aid in correlating it with the makers of the fluted points and other implements characteristic of the Folsom complex.[7] Both may be the remains of those people, yet such a conclusion is not tenable without the support of accompanying artifacts because both regions were occupied by other and later Indian groups. Hence, it must be said that so far as his physical characteristics are concerned, Folsom man is still an unknown person. There is no information on the type of shelter he may have used. On the other hand it seems obvious that he was a typical hunter depending entirely upon game—mainly bison, but occasionally the mammoth and a stray camel, deer, and antelope—for his maintenance and sustenance. He no doubt supplemented his preponderant meat diet with wild seeds and "greens" but did not cultivate his own vegetal food. He probably did not settle long in one place but traveled wherever the animals moved in order to support himself. This factor unquestionably is linked with that of the spread of aboriginal man to North America and the question of when that movement began. There would be little incentive to migrate to a region where

[6] Figgins, 1933.
[7] Figgins, 1935; Roberts, 1937.

animals were scarce or absent; consequently, the men must have followed the game, and the routes of travel must have been more or less the same.

A complicating ramification in the study of the problem is that of the glaciation and extent of the ice sheets over North America. Many of the mammals that crossed over from Asia during Pleistocene times seemingly came by way of Bering Strait, either over the ice or by means of a land bridge in that vicinity. Some of them came during interglacial stages, others toward the end of the Late Glacial and in the Early Postglacial. The main pathway from the unglaciated area in central Alaska seems to have been east to the Mackenzie and then southeastward along that river and the eastern slopes of the Rocky Mountains into the Plains. This corridor apparently was open for a time prior to the last glacial stage and then became the first land route available when the glaciers began to melt. Subsequently, a route due south along the Fraser River opened, and the Pacific coast strip also became available for land travel over most of its length. Some of the animals hunted by Folsom men, the mammoth particularly, probably penetrated into the area in interglacial times, because opinion is that elephants and bison were missing in Alaska in Late Glacial and Early Postglacial times, while others undoubtedly migrated with the opening of the cordilleran corridor. Present indications are that it was at the latter stage that the hunters first ventured into this vast New World. Many of the animals that served as game were essentially the same as exist today, but as the people moved toward the south they found and killed forms that are now extinct, such as the mammoth, mastodon, some species of bison, the camel, and the ground sloth. Although these extinct forms are considered as Pleistocene mammals, there appears to be no question but that many of them may have lived on into Postglacial times. For this reason the mere association of man-made tools with bones of such creatures does not necessarily indicate a Pleistocene date. Other complications are brought about by the probability that some forms—the mammoth, mastodon and musk-oxen—followed the retreating glaciers and, when found in some of the more northern districts, are not actually as old as those uncovered in southern localities. However, two of the Folsom sites, Folsom and Clovis-Portales, have been placed at the close of the Pleistocene with mention of the possibility that they really belong within that period, and the Lindenmeier site has been assigned to a phase within the Pleistocene on evidence apart from animal remains. For this reason it becomes increasingly clear that the Folsom hunters must have drifted down along the opening corridor not long after the beginning of the glacial retreat.[8]

[8] Antevs, 1935 b; Johnston, 1933.

Mention should be made of the distribution of fluted points. The type has been known for a long time and variations of it have been found from the Rockies to the Atlantic, from the Plains Provinces of Canada to the Gulf of Mexico. It is represented in collections in numerous museums and in at least one case has been called by another name, the Seneca River point. It did not attract particular attention until the finds at Folsom. This was largely because most of the examples were picked up from the surface and were without definite significance. The main area of concentration for the type lies in a strip that stretches from Alberta and Saskatchewan in the north to New Mexico and western Texas in the south. Smaller centers are found in the eastern and southern States, notably western New York, Ohio, Tennessee, and in a district along the boundary line between central Virginia and central North Carolina. Only a few sporadic examples have been found west of the Rockies and most of them come from two districts in California, one in the southern part of the State and the other in the northern. There are two main classes of fluted points, one represented by the Folsom, Lindenmeier, and similar forms found in the western plains strip along the Rockies, and a larger, more generalized one embodying most of the characteristics but not exhibiting the same degree of skilled workmanship in their manufacture and for the most part lacking the fine secondary retouch along the edges. The latter form is the one with the wide distribution (pl. 15). The question is whether all should be called Folsom points or if there should be some designation that did not carry the implication of equal age. Dr. Howard and the writer have used the terms Folsom-like and Folsomoid to indicate the distinction, but both have been frowned upon by the archeological taxonomists. H. C. Shetrone of the Ohio State Museum has suggested that they be definitely termed Fluted Points as a class and the various forms then be more specifically designated by place names such as Folsom, Lindenmeier, Clovis, et cetera. This proposal has considerable merit and would remove much present confusion. However, a committee appointed at the symposium on early man decided that the name Folsom should be applied to all. Such being the case it would seem that definite qualifiers should be used, as in the case of Mr. Shetrone's suggestion, and the various examples be known as Folsom-Folsom, Lindenmeier-Folsom, Ohio-Folsom, or California Folsom.

The significance of the fluted points occurring east of the Mississippi River is open to question. There is still no evidence suggesting their possible age or place in the main archeological picture. The vast majority are surface finds and although there seem to be several centers, as mentioned previously, where they are picked up in comparatively large numbers, nothing has come to light that would indicate their relationship to the cultural remains present in those

areas. The fact that the eastern examples bear a striking resemblance to those in the West does not make them of equal antiquity. They may represent a survival of a highly specialized implement in later horizons. Some students take a different view and regard the individuality of the form together with its apparent absence from the recognized complexes in the East as a manifestation of its greater age. On the basis of the distribution concept as an index to age—a theory substantiated in some respects by evidence that tends to indicate that there is a correlation between type and distribution, so that the larger the area covered the older the form—the eastern examples would indicate more antiquity than the western. But until specimens are found in association with fauna comparable to that in the West and accompanied by other implements now known to belong to the Folsom complex, conclusions must be withheld. The question becomes more complicated when it is recalled that the Folsom implement makers no doubt chipped a variety of sizes and qualities of points for use in hunting different kinds of game, and the larger forms may merely represent those intended for big animals.

The California occurrences raise a number of questions. There apparently is so marked a gap between them and the major centers of the type that the problem of the relationship is difficult to solve. Furthermore, many of the purported Folsom points from that region are so nondescript in form that it requires stretching of the Folsom-like category to the utmost to include them. In only a very few cases is there an approximation of similarity to the Folsom-Folsom or Lindenmeier-Folsom specimens. This matter of identification, however, is one that has proved troublesome in all parts of the country, and there has been a tendency to include points with a basal thinning, not an actual facial fluting, in the Folsom classification. An explanation for the presence of materials attributable to the Folsom complex in California is hard to find in the light of present knowledge. They may have worked westward from the southern plains area, but traces of such a movement are scarce, and suggestions that the reverse was the case, that the Folsom hunters worked east from southern California and thence upward into the plains, seem entirely unwarranted in the light of knowledge of the migration of the animals that formed the chief source of sustenance and the occurrence of materials in that area. It is more likely that the Pacific coast was reached by groups drifting down the Fraser River corridor after it had opened. Coming from the upper plains reservoir of hunting peoples, they could well have possessed similar implements. While too little is known as yet concerning the problem to make any definite statements, it may be mentioned that in view of the indications that the Fraser route opened subsequent to that of the western plains corridor, the Cali-

fornia remains may represent a somewhat later phase and for that reason show some differences.

In closing, attention should be called to the fact that there are other traces of early occupancy in portions of the plains area, particularly in Minnesota and Texas. In some cases there are indications that the remains may antedate those of the Folsom complex, in others that they are contemporaneous with it. Although detailed consideration of these occurrences is not pertinent to the present discussion, it is essential to mention them because they have significance in connection with the study of early man in America, and the matter of their relationship to or bearing on the Folsom problem is a phase of the subject still to be studied.

LITERATURE CITED

Antevs, Ernst
1935 a. The occurrences of flints and extinct animals in pluvial deposits near Clovis, N. Mex. Pt. 2, Age of the Clovis lake clays. Proc. Acad. Nat. Sci. Philadelphia, vol. 87, pp. 304–312.
b. The spread of aboriginal man to North America. Geogr. Rev., vol. 25, No. 2, pp. 302–309, April.

Brown, Barnum
1929. Folsom culture and its age (with discussion by Kirk Bryan). Bull. Geol. Soc. Amer., vol. 40, pp. 128–129.

Bryan, Frank
1938. A review of the geology of the Clovis finds reported by Howard and Cotter. Amer. Antiquity, vol. 4, No. 2, pp. 113–136, October.

Bryan, Kirk
1937. Geology of the Folsom deposits in New Mexico and Colorado. *In* Early Man, as depicted by leading authorities at the International Symposium, Academy of Natural Sciences, Philadelphia, March 1937, pp. 139–152. J. B. Lippincott Co., London.

Coffin, Roy G.
1937. Northern Colorado's first settlers. Publ. by Colorado State Coll., Fort Collins.

Cook, H. J.
1927. New geological and paleontological evidence bearing on the antiquity of mankind. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, No. 3, pp. 240–247, May–June.

Cotter, John L.
1937. The occurrence of flints and extinct animals in pluvial deposits near Clovis, N. Mex. Pt. 4, Report on excavation at the gravel pit, 1936. Proc. Acad. Nat. Sci. Philadelphia, vol. 89, pp. 1–16.
1938. The occurrence of flints and extinct animals in pluvial deposits near Clovis, N. Mex. Pt. 6, Report on field season of 1937. Proc. Acad. Nat. Sci. Philadelphia, vol. 90, pp. 113–117.

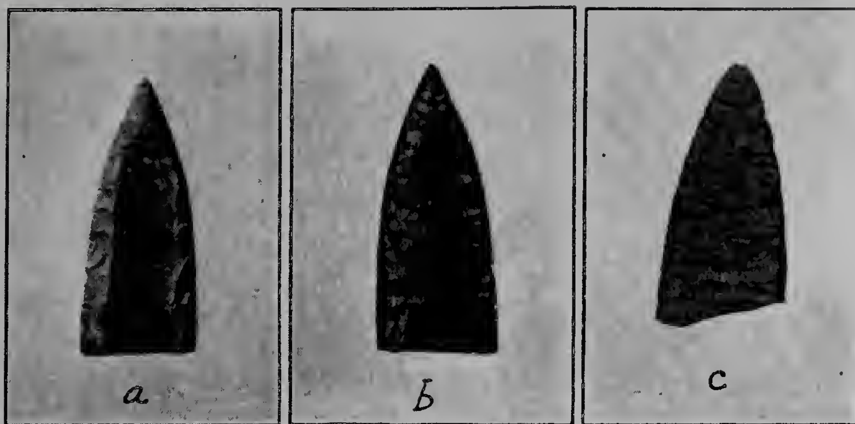
Figgins, J. D.
1927. The antiquity of man in America. Nat. Hist., Journ. Amer. Mus. Nat. Hist., vol. 27, No. 3, pp. 229–239, May–June.
1933. A further contribution to the antiquity of man in America. Proc. Colorado Mus. Nat. Hist., vol. 12, No. 2.
1935. New World man. Proc. Colorado Mus. Nat. Hist., vol. 14, No. 1.

Howard, Edgar B.
1935 a. Evidence of early man in North America. Mus. Journ., Univ. Mus., Univ. Pennsylvania, vol. 24, Nos. 2–3, pp. 61–175.
b. The occurrence of flints and extinct animals in pluvial deposits near Clovis, N. Mex. Pt. 1, Introduction. Proc. Acad. Nat. Sci. Philadelphia, vol. 87, pp. 299–303.

Johnston, W. A.
1933. Quaternary geology of North America in relation to the migration of man. *In* The American Aborigines, their origin and antiquity. 5th Pacific Sci. Congr., Canada, 1933, pp. 11–45.

Roberts, F. H. H., Jr.
1935. A Folsom complex: preliminary report on investigations at the Lindenmeier site in northern Colorado. Smithsonian Misc. Coll., vol. 94, No. 4.
1936. Additional information on the Folsom complex: report on the second season's investigations at the Lindenmeier site in northern Colorado. Smithsonian Misc. Coll., vol. 95, No. 10.
1937. New World man. Amer. Antiquity, vol. 2, No. 3, pp. 172–177, January.

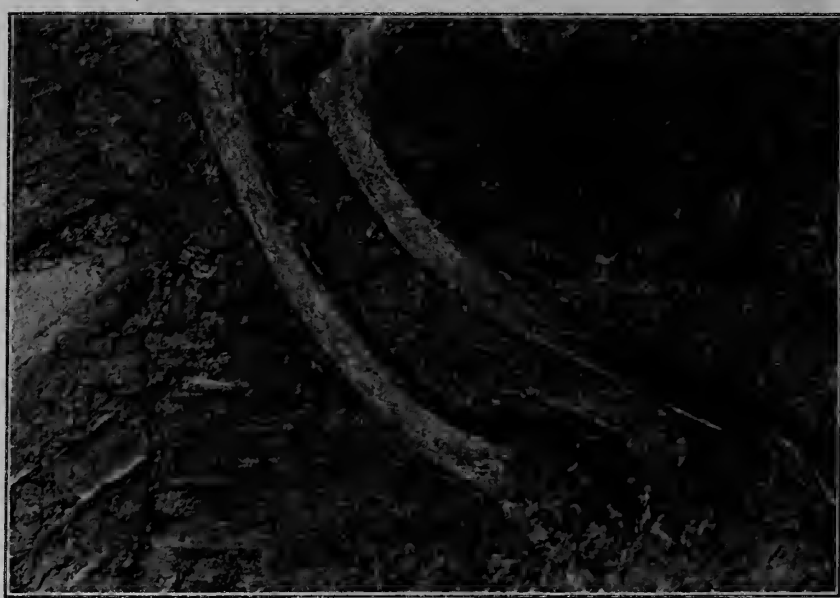
Stock, Chester, and Bode, F. D.
1936. The occurrence of flints and extinct animals in pluvial deposits near Clovis, N. Mex. Pt. 3, Geology and vertebrate paleontology of the later Quaternary near Clovis, N. Mex. Proc. Acad. Nat. Sci. Philadelphia, vol. 87, pp. 219–241.



1. *a, b, c*, original points from Folsom pit. *a* and *b*, different sides of same specimen.

2. Fragment of stone in place near bone and portion of point that fits small piece. (Pictures on this plate courtesy of Colorado Museum of Natural History).

1. Folsom pit in summer of 1927. Point and bones in situ at left of standing figure. (Photograph by author.)

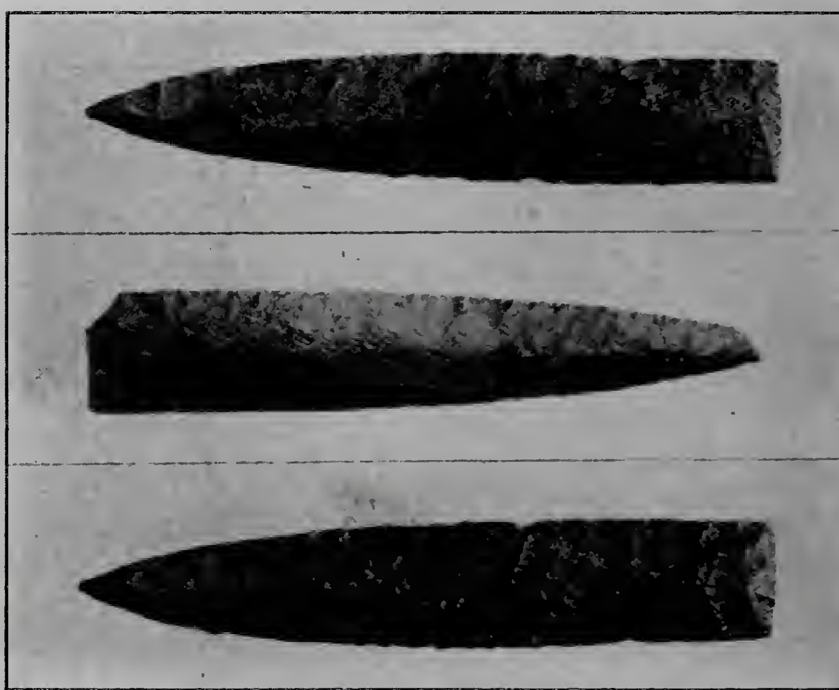


2. Point and bison ribs in situ. (Photograph courtesy of Colorado Museum of Natural History.)

1. General view of "blow-out" between Clovis and Portales.

2. Mammoth tusk weathering out of old lake bed. (Pictures on this plate courtesy of Dr. E. B. Howard.)

1. Part of trench at Clovis sites where two mammoth skeletons and bison were uncovered in direct association with Folsom points. (Picture courtesy of Dr. E. B. Howard.)



2. One characteristic type of Yuma points.

1. Looking east across Lindenmeier site. Cross indicates excavation area. (Photograph by author.)

2. View across Lindenmeier site toward the southwest. Excavations in central portion of picture. (Photograph by author.)

1. Deep pit in ravine bank at beginning of investigations. (Photograph by author.)

2. Large trenches cutting across site toward deep pit in ravine bank. (Photograph by author.)

1. Sifting material at lower end of trench leading into pit. (Photograph by author.)

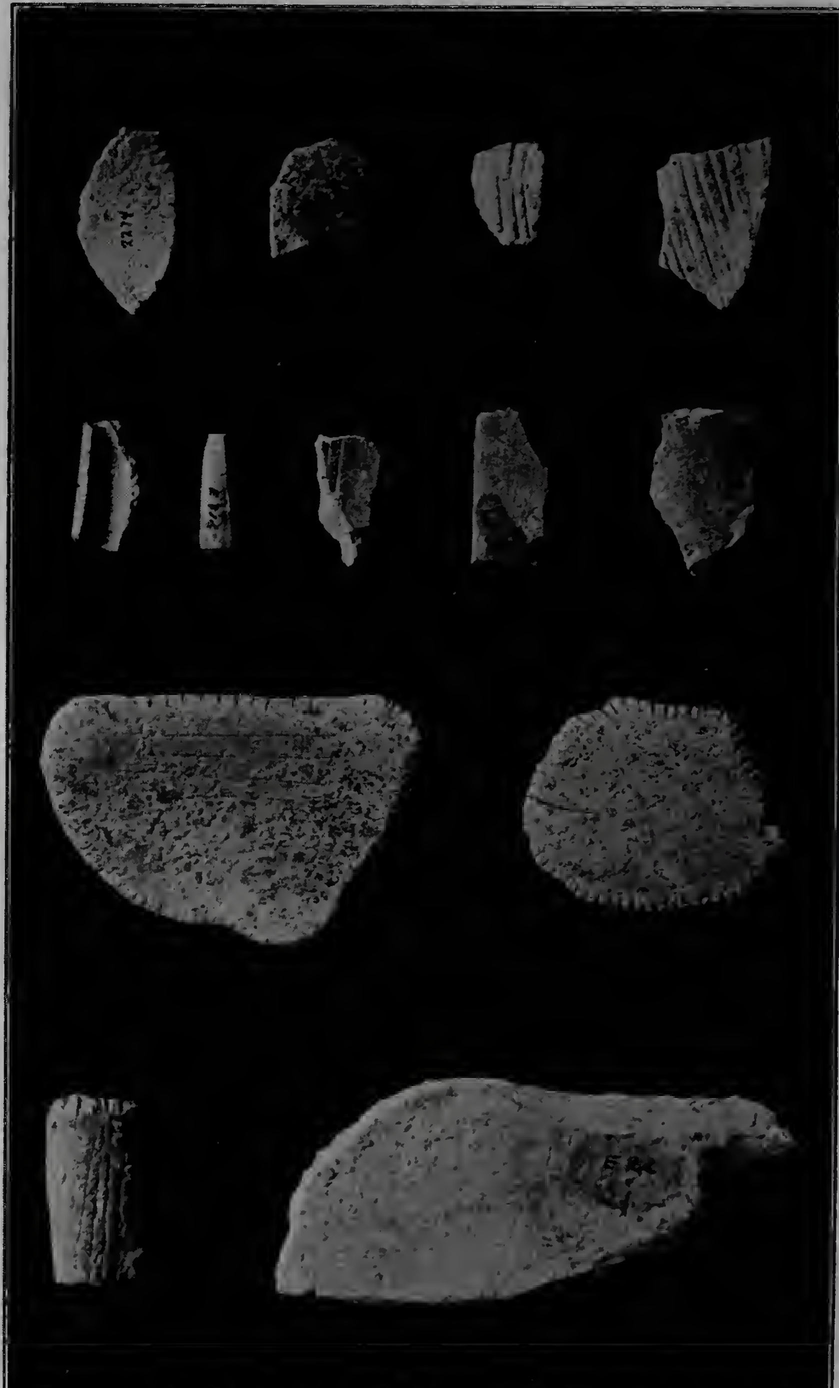
2. End of large trench. Workman standing on level where artifacts were found. (Photograph by author.)

1. Articulated foreleg of bison in situ at Lindenmeier site. (Photograph by author.)

2. Tip of projectile point lodged in bison vertebra.

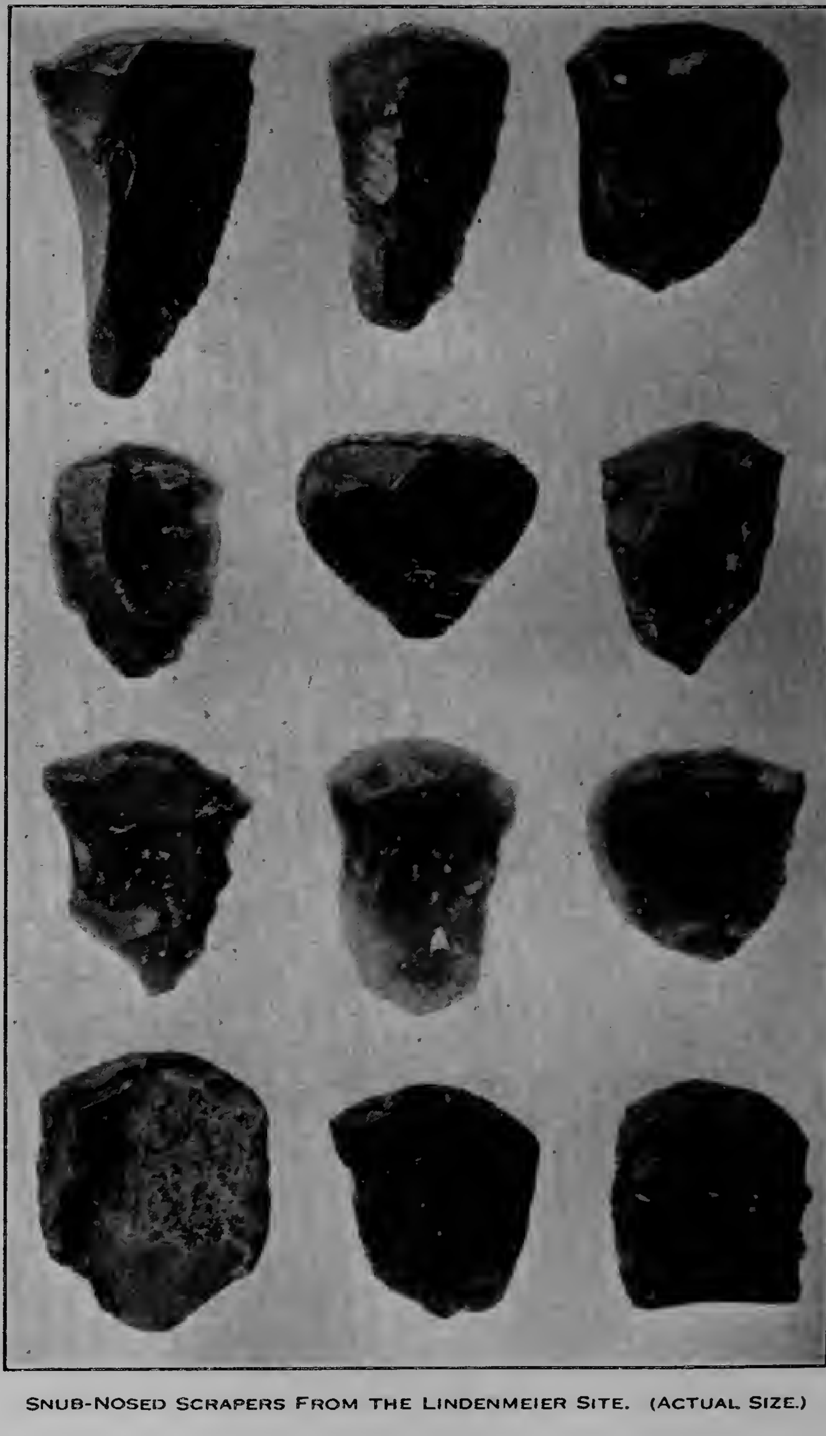
1. Workman uncovering bone fragments and stone tools at Lindenmeier site. (Photograph by author.)

2. Split bones and stone implements in situ. Small numbers indicate artifacts. (Photograph by author.)



ORNAMENTED BONE SCRAPS FROM LINDENMEIER SITE. (ACTUAL SIZE.)

FOLSOM POINTS FROM THE LINDENMEIER SITE. (ACTUAL SIZE.)



SNUB-NOSED SCRAPERS FROM THE LINDENMEIER SITE. (ACTUAL SIZE.)

SIDE SCRAPERS FROM THE LINDENMEIER SITE. (ACTUAL SIZE.)

1. Bones and stone objects at base of heavy soil zone. (Photograph by author.)

2. Workmen removing bone scraps and stone implements from layer below heavy soil zone. (Photograph by author.)

TYPICAL FORMS OF POINTS FOUND IN SOUTHERN AND EASTERN STATES.
(ACTUAL SIZE.)

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1939

(Publication 3586)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
APRIL 3, 1940

EXCAVATIONS AT THE LINDENMEIER SITE CONTRIBUTE NEW INFORMATION ON THE FOLSOM COMPLEX

By FRANK H. H. ROBERTS, JR.
Archeologist, Bureau of American Ethnology

Continuance of excavations at the Lindenmeier site in northern Colorado and careful exploration of the deeply gullied terrain for many miles in all directions in an effort to obtain additional information and further traces of Folsom man, the nomadic hunter who tarried in that district during the closing days of the last ice age, constituted the activities of one Bureau of American Ethnology-Smithsonian Institution field party in the summer of 1939. The digging produced new and augmenting data, but the reconnaissance failed to locate more than sporadic traces of former occupancy, none comparing either in extent or quality of evidence with the main site.

Previous investigations established the fact that the Lindenmeier site was a former camping place occupied when glaciers still lingered in the mountains; when the climate was cooler and more moist; when species of bison, camel, and mammoth, animals now extinct, roamed the western plains; and when the topography differed from that of today. The earlier digging revealed that what now appears as a terrace was originally part of a valley, the bottom dotted with meadows, marshes, and bogs furnishing food, water, and wallowing places for the animals, and the gently inclined lower slopes providing a suitable resting spot for the aboriginal hunters. In addition to the game that served to satisfy the requirements for food and probably for the materials needed for tents and such clothing as was worn, the region also supplied stone in the form of nodules, weathering from surrounding deposits, from which to fashion tools. That full advantage was taken of these resources is shown by the numerous scattered assemblages with implements in association with cut, split, and burned bones, and concentrations of chipper's debris, the minute stone splinters and larger unused flakes resulting from the manufacture of various kinds of articles. These materials are found along the old level of occupation several feet below the present surface.

The 1939 excavations consisted of the removal of the overburden, ranging from 3½ to 5½ feet in thickness, from some 1,540 square feet of the camp area, the sinking of 10 test pits in unsampled portions of the site, and making examinations of outcroppings of the

Fig. 93.—General view of Lindenmeier site. Arrow points to main excavations. Light spots on ground to right above upper ravine bank indicate digging of previous seasons.

Fig. 94.—Portion of the main excavations of the 1939 season.

FIG. 95.—Trench extending from main pit shows upward slant of occupation level and demonstrates former existence of bordering ridge.

FIG. 96.—Portion of main pit showing bone scraps and section of bison jaw in position below dark soil zone.

archeological stratum in the banks of a deep ravine that traverses part of the old valley bottom (fig. 93). Exposure of the former surface of occupation started from the side of a test trench dug in 1938 and continued up, down, and along the slope (fig. 94). The layers of earth in the overlying deposits at this part of the site hold so consistent a level in relation to the course of the old valley and have such a gradual slant in the other direction that a narrow trench was cut through from the main excavation to the edge of the terrace to ascertain the nature of their termination. They end on the surface a few feet from the escarpment and clearly show that they formerly continued on the same gradient (fig. 95), for an undeterminable distance. The feature is significant because it augments and emphasizes previous indications that the valley once was bordered by a ridge long since eroded away. Some of the material was swept down across the site, forming the layers above the archeological horizon, but the bulk of it has been carried away in the opposite direction, thus producing the terracelike character of the formation.

The thick, dark-colored stratum apparent in the photographs just above the floor of the excavation is a soil zone produced by lush vegetation during a period of heavy precipitation when growing conditions were more favorable than those of recent times. The layer is important because it was the means of correlating the site with geologic phenomena attributable to the waning of the Glacial period. The artifacts and bones occur along the upper surface and in the lighter-colored stratum below, some projecting into the zone above (fig. 96). The light layer consists of a mixture of wind-blown sand and decomposed material from the top of the tufaceous clay deposit underlying the whole area. The stratum is evidence for a dry and windy era associated with a minor oscillation in the last ice sheet and establishes a slightly earlier occupation than previously supposed. The positions of the artifacts and bones show inhabitation before the onset of the wet cycle and that tenancy persisted for a time after its inception but did not continue throughout its duration. The climate may have become too damp, possibly somewhat cooler as well, and as a consequence the animals and people moved on, probably farther south along the edge of the Plains, where traces of their former presence appear in several places.

The excavated area yielded more specimens than any of comparable size yet dug. The artifacts comprise typically fluted Folsom points, fluted knives, knives made from channel flakes removed from the faces of the points, other kinds of flake knives, a large variety of scrapers including several forms of the spokeshave type, flakes with

FIG. 97.—Workman pointing to bone bead in situ, pieces of bison bones partially uncovered. Inset shows two forms of beads. Upper specimen decorated with incised lines.

FIG. 98.—Test excavations in ravine bank. Standing figure in central foreground is on old surface of occupation.

graver's points, large choppers and hand hammers, pigments in the form of hematite and red and yellow ochers, bone punches and awls, pieces of decorated bone of unknown function, and tubular bone beads. An interesting feature in the material from this portion of the site is the large number of channel flakes and the quantity of chipper's debris. These suggest proximity to the place where points were made, probably to the actual habitation area of some of the group. There are several new types of knives and scrapers in the collection and the beads (fig. 97) are the first to be found in the Folsom complex. They were made from shafts from long bones. Unfortunately, the process of manufacture removed the criteria for identification, but they seem to be rabbit and bird. One of the specimens is decorated with a series of short, parallel lines cut into its surface.

Because most of the bone material of the 1939 season is the residue from meals, it is too scrappy to permit recognition of all of the animals represented. There is no question, however, of the presence of bison, antelope, deer, and rabbit. The basal portion of one bison skull was found with the horn cores still intact. The distance between the tips of the cores is 36 inches (914.4 mm.). This measurement, as well as the size and contour of the cores, shows the animal was one of the extinct species. Modern buffalo skulls from this general area range from 23 to 24 inches (584.2 to 609.6 mm.) between the tips of the cores. The older form was also much larger in all other respects.

The digging in the ravine bank, across from the main excavations, demonstrated that the horizon was the same although more deeply buried (fig. 98). The 20 feet of overburden is due to the fact that here the surface of occupation was farther down the slope toward the valley bottom and the deposition of eroded debris was greater than that at higher levels. The material was still on the south slope of the old valley, however, as has been the case in all previous finds. As the dark soil zone approaches the old bottom it becomes thicker and takes on the appearance of silt, such as occurs in bogs and meadows. Bone fragments found there are better preserved than those from higher up the slope. This condition is attributable to their having fallen into muck where they were sealed from the air and other agents contributing to rapid disintegration. The various test pits indicated the location of other concentrations of archeological material and helped to delimit the area of occupation.

The 1939 season, like its predecessors, failed to produce any human bones, and the physical nature of Folsom man is still unknown. There is no satisfactory explanation for the lack of skeletal material. It probably is present and simply has not been found in the digging.

SMITHSONIAN INSTITUTION

EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1940

(Publication 3631)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
APRIL 3, 1941

LATEST EXCAVATIONS AT LINDENMEIER SITE ADD TO INFORMATION ON THE FOLSOM COMPLEX

By FRANK H. H. ROBERTS, Jr.
Archeologist, Bureau of American Ethnology

Evidence that Folsom man, one of the first American big-game hunters, made and used fine bone needles with eyes, and that three types of projectile points found in the western part of the Great Plains represent sequent stages in the occupation of the area was part of the information obtained by the Bureau of American Ethnology-Smithsonian Institution expedition in northern Colorado during the 1940 field season.

Excavations at the Lindenmeier site (fig. 79), an important archeological location because it once was a camping place for groups of Folsom people, were resumed June 3, continued through July and August, and were brought to a close on September 20. The summer's digging started at a portion of the site where work stopped the previous year (fig. 80) and the overburden, ranging from 3 to 6 feet in depth, was removed from 2,125 square feet of the former habitation area. This exposed numerous concentrations of cultural material consisting of stone and bone implements and camp debris (fig. 81). Over 1,000 artifacts, the largest number obtained during any single season's excavation at the site, and numerous animal bones came from these assemblages. Included in the collection of artifacts are bone needles, mentioned above, bone awls, bone punches, bones with spatulate ends, stone projectile points, many of the flakes removed to form the facial grooves, scrapers of various kinds, knives, hand hammerstones, and stones used for smoothing wooden objects and, possibly, for dressing skins. One interesting occurrence was the finding of a channel flake that fits a portion of a point obtained during the first season's work. The fragments came from locations some 450 feet apart.

The importance of the needles is that they demonstrate the presence of this type of implement at an earlier period in North America than previously supposed and also in their implication of the use of some kind of tailored clothing and foot gear. While there was the assumption that Folsom man relied on hides from the animals he hunted for protection against the rigorous climate of the closing days of the last ice age, this is the first indication that he may have fashioned actual garments from that material. With such needles and

FIG. 79.—Approaching thunderstorm at the Lindenmeier site, northern Colorado. Main portion of site lies between camp at the left and hill at the right.

FIG. 80.—Looking south across the Lindenmeier site. The 1940 excavations were above the ravine bank near the right border of the photograph; expedition camp at the left.

FIG. 81.—A portion of the excavations. Workmen at the right are just beginning to remove the specimen-bearing stratum.

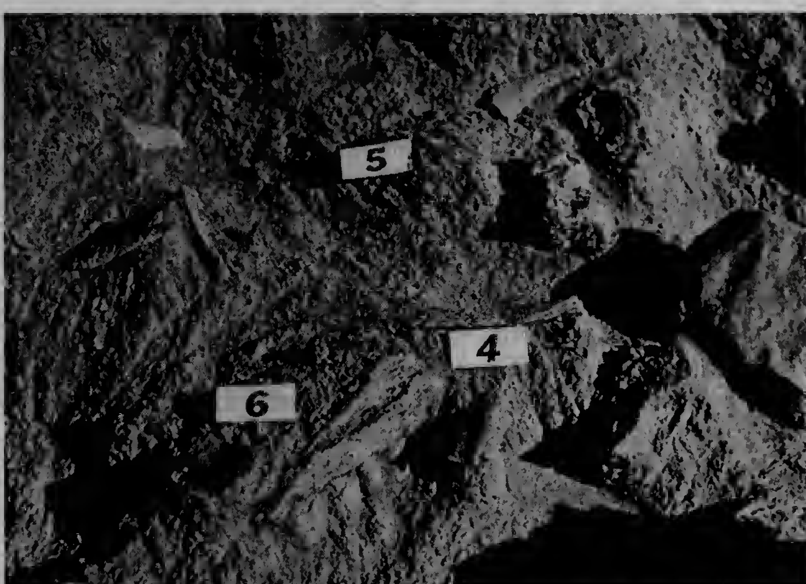


FIG. 82.—Archeological objects and pieces of cut bison bones in situ. 4, a characteristically fluted Folsom point; 5, the basal portion of a broken point; 6, a stone scraping tool. Portion of bison jaw lies between 4 and 6.

sinew for thread a serviceable job of sewing was possible. The needles apparently were made from splint bones from deer or bison.

The three types of projectile points are the characteristically fluted Folsom (fig. 82); a point that in its general outline resembles the Folsom but has only a thinned base formed by the removal of several short, narrow flakes instead of a single broad, long one as in the case of the Folsom; and a triangular-bladed form with a long, broad tang. They occur in the preceding order with the Folsom at the bottom, the oldest level. The significance of this evidence is that it establishes the priority of the Folsom type. On the basis of typological studies it has been suggested that the thinned-base type was a preliminary stage in the development of the facial fluting typical of the Folsom points, but it now appears that it represents a break-down in the form. The type with the long, broad tang occurs in a distinct stratum that is definitely later in time than the Folsom horizon. Similar points have been found at several sites in western Nebraska and Kansas and have been regarded, by some investigators, as contemporary with the Folsom. This is now disproved.

In addition to the above-described work, nine test trenches were dug in portions of the site not investigated previously. None of these revealed promising locations for further excavations, and the openings were not enlarged. Evidence obtained from many test pits, those put down in previous years as well as those of the current season, indicates that the area where the major digging was done was the main camping place on the old valley bottom.

During the month of August the writer supervised student excavations at the University of New Mexico field session in the Chaco Canyon, N. Mex., and visited several sites in New Mexico and Arizona where reports indicated the possibility of relatively early occupancy. The most important of these is one located south of the town of San Jon, approximately 25 miles southeast from Tucumcari, in eastern New Mexico. There large numbers of cut and split animal bones, most of them in an advanced stage of fossilization, are weathering from deposits along the edge of the Staked Plains. Associated stone flakes and artifacts indicate a former hunting grounds or camping place. Projectile points from the assemblage suggest an early Yuma type, and it is possible that valuable information on the proper place in the archeological picture of the area of that much-debated form could be obtained by careful excavation of the site. While the writer was absent from the Lindenmeier site, work continued under the supervision of Charles R. Scoggin, a student from the University of Colorado, who has been a member of the field party during all but one of the several seasons of excavation there.

The Lindenmeier Valley viewed from the west. Piracy by a tributary of Boxelder Creek has beheaded the valley. High Plains escarpment to left, Colorado Piedmont to right.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 99, NUMBER 2

GEOLOGIC ANTIQUITY OF THE LINDENMEIER SITE IN COLORADO

(WITH SIX PLATES)

BY
KIRK BRYAN
AND
LOUIS L. RAY
Harvard University

(PUBLICATION 3554)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
FEBRUARY 5, 1940

CONTENTS

ILLUSTRATIONS

PLATES

TEXT FIGURES

GEOLOGIC ANTIQUITY OF THE LINDENMEIER SITE IN COLORADO

By KIRK BRYAN and LOUIS L. RAY
Harvard University

(With Six Plates)

INTRODUCTION

The antiquity of man in America is a problem of many ramifications which is as yet largely unsolved. The geologic approach is attended with difficulties which arise from the lack of immediate precedent as to method and from the lack of a well-established geologic chronology applicable to the whole world. However, the extensive culture layer at the Lindenmeier site in Colorado, containing a wide variety of stone implements associated with the bones of extinct animals, provides an unparalleled opportunity for an approach to the problem on several lines. The methods evolved and the chronology established during a 4-year campaign are here set forth. The chronology is, however, local, and its correlation with a time sequence of world-wide recognition involves numerous assumptions whose validity requires confirmation. The European chronology is being continually improved and is, as yet, not directly applicable to North America. Only by extensive studies of late Pleistocene time from the geological, paleontological, and archeological standpoints will a thoroughly sound world-wide chronology be attained. By the convergences of lines of evidence derived by these three methods, combined with the results of paleobotany, it will be possible eventually to date events of the Pleistocene in western United States in terms of the chronology already available in northern Europe.

Interest in the later phases of the geologic story in North America has, heretofore, lacked the stimulus provided by archeological finds in deposits of geologic antiquity. Many badly authenticated or even fraudulent discoveries, purporting to have some measure of antiquity, have cast a cloud of suspicion on claims of the presence of any man in North America earlier than the late-neolithic American Indian. However, in 1927, the discovery of the fluted points, now generally called Folsom, in association with extinct bison (Figgins, 1927, and Brown, 1929), led to a veritable revolution in thought among con-

servative anthropologists. Here, for the first time, implements distinct in type from the ordinary "neolithic" points, characteristic of the American Indian, were indubitably contemporaneous with an extinct animal. The considerable antiquity thus implied was admitted promptly by many leading anthropologists and led to much activity. From the three standpoints of typology, of vertebrate paleontology, and of general geology, further progress appeared possible.

Unfortunately, conditions at the original site were not favorable for geologic dating (Bryan, 1929 and 1937; Roberts, 1935). Furthermore, a reconsideration of the known stratigraphic position of extinct vertebrates indicates that many species may have survived into comparatively recent time (Romer, 1929 and 1933). Mere association with the remains of extinct animals is no longer considered a measure of an antiquity as early as, or earlier than, the climax of the last glaciation. Many extinct species are now thought to have survived into the last few thousands of years. These species are considered to be definitely Late-glacial, or Post-glacial in the European sense.

Many observers, both trained archeologists and a great group of amateurs, have enlarged our knowledge of the distribution of Folsom and Folsom-like points. Many finds of points associated with extinct animals have been reported (Cook, 1927; Schultz, 1932; Figgins, 1933; Sellards, 1938; Bryan and C. N. Ray, 1938). Also, other stone cultures of considerable antiquity have been discovered (E. W. and W. H. Campbell, 1937; Bryan, 1938; C. N. Ray, 1938), so that now we are confronted, not with a single problem of antiquity, but with a group of problems.

In order that the geologic method of attack may be used in dating the increasing number of finds of Folsom and other cultures, it is necessary to establish: 1, that the cultural objects are associated with a definite bed or beds; 2, that these beds are related to some definite geologic event; 3, that this event is related to other events or is of wide geographic extent; 4, that this event and related events are also related to some known geologic chronology. Such a sequence is obviously a rigorous requirement which may not always be met.

The foregoing relations appear to be characteristic of the Lindenmeier site, discovered in 1934, and intensively investigated by Dr. F. H. H. Roberts, Jr., of the Smithsonian Institution, from 1934 to 1938. Here, as described by Roberts (1935, 1936, and 1937), there is a layer of dark earth, containing bones of extinct animals and artifacts, buried in places under material 14 feet thick. This layer has been traced in outcrop and by excavation for more than 2,000 feet east and west, and more than 300 feet in a north and south direction.

Archeologically, the site is the most important find of recent years, because it has yielded over 2,000 stone implements, including, besides the typical fluted points, other points, and a wide variety of scrapers and similar artifacts, sufficient to define the stone culture by typology. Thus, the date of the culture becomes of importance.

The culture layer lies on the floor and southern slope of a valley abnormal in the area. Locally, this valley, because of stream piracy, retains part of its old floor, which is preserved downstream as a mere terrace remnant. Thus the valley and its culture layer may be related to a terrace which commonly occurs also on nearby streams. In this instance there are present the first two requirements mentioned above, the definite culture stratum, which can be related to a geologic event—the formation of the unusual Lindenmeier Valley, and of the contemporaneous terraces in the local streams.

These streams are small and ephemeral tributaries of a perennial river, the Cache la Poudre, which rises in the mountains and flows out onto the plains. The terraces of the tributaries may be traced down their courses and correlated with those of this main river. The Cache la Poudre is in turn a tributary of the master stream of the region, the South Platte River (see map, fig. 1), which drains most of the northern part of the Colorado Front Range and the adjacent Colorado Piedmont. As the present gradient of the South Platte River is a local base level, and as its successive positions in the past have been local base level, it follows that the terraces of all the streams in the region are similar in number and relative age. Thus, the third requirement is fulfilled, that the geologic event be of wide geographic extent.

Furthermore, the Cache la Poudre and other major tributaries of the South Platte, rise in the Rocky Mountains, an area recently glaciated. Some of the terraces, particularly the lower and younger terraces here involved, may be traced upstream and related to the episodes of glaciation in the mountains. Now, glaciation is a phenomenon that is world-wide. In the past the glaciers were not only more extensive than now, but formed and advanced at least four times during the Pleistocene. Although there is no absolute proof that growth and advance of glacial ice was synchronous over the earth, nevertheless, there is much confirmatory evidence, such as an apparent uniformity in the total number of major ice advances, and an equally close similarity in the episodes attending the final retreat of the last great glacial advance. Thus, glacial chronology is, if not a perfect time record, at least a standard chronology.

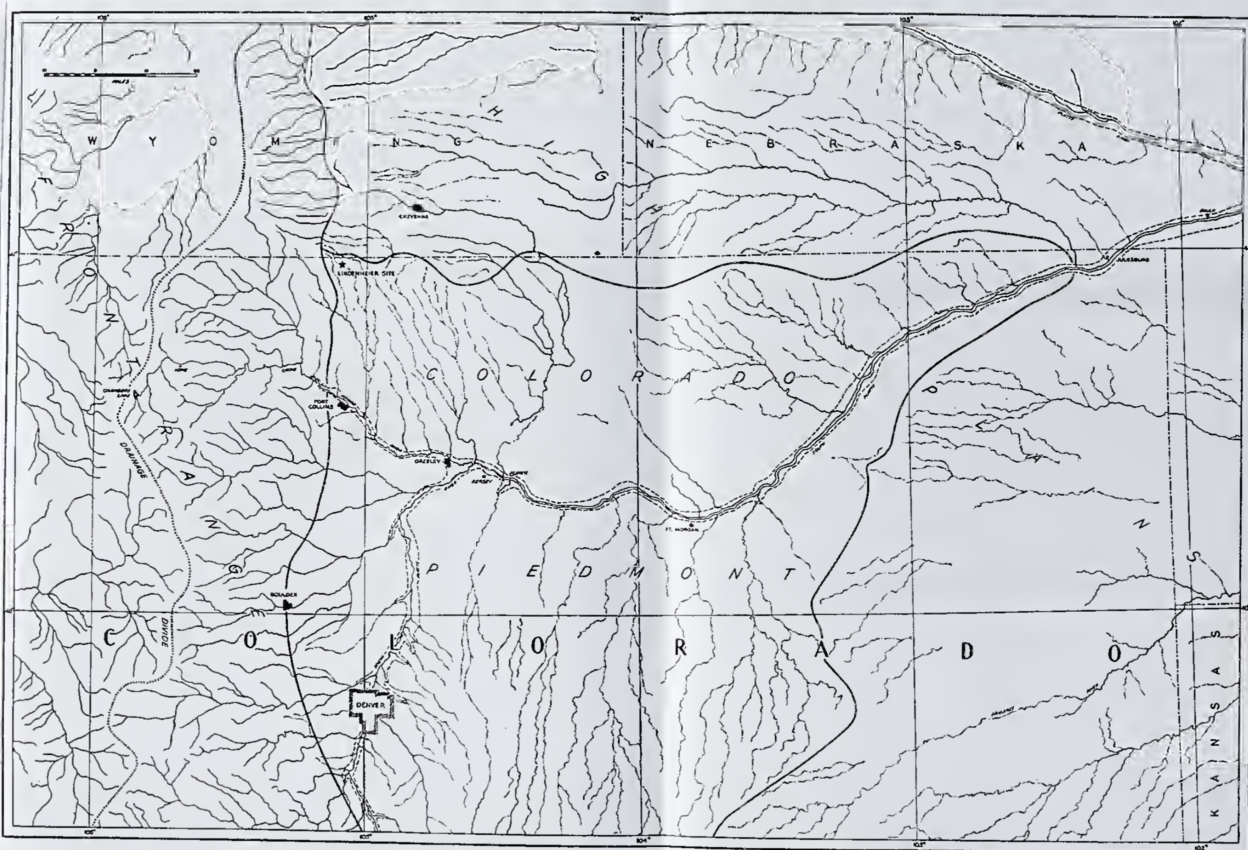


FIG. 1.—Map of the major physiographic subdivisions and drainage of northeastern Colorado and adjacent territory.

ACKNOWLEDGMENTS

During the summer of 1935 Bryan spent a month at the Lindenmeier site, studying the geologic chronology and making a topographic map of the Lindenmeier Valley, in which task he had the volunteer assistance of Franklin T. McCann and John T. Hack. The topographic map was later extended by E. G. Cassedy, of the Smithsonian Institution, who has spent several weeks during the following seasons making this and other maps and sketches of the Lindenmeier Valley and adjacent country. During the summers of 1936 and 1937 the geologic work was extended by Ray into the main drainage systems of the South Platte and the Cache la Poudre Rivers and into the glaciated portions of the Cache la Poudre Canyon in the northern Colorado Front Range. He was assisted by Thomas W. Steptoe in 1936, and during the later parts of both the 1936 and 1937 field seasons by Charles R. Scoggin. In both years Bryan spent several days with Ray in conferences at critical places in the field. The cost of the field work was met in large part by grants from the Smithsonian Institution. In the summer of 1938, under a grant from the Milton Fund of Harvard University, Ray extended the study of the glacial sequence and the chronology of the later Pleistocene over a large part of the Southern Rocky Mountains.

The writers wish to thank their assistants and the many local residents, especially Miss Agnes Zimmerman and Mr. and Mrs. Bryan Gladstone, Home, Colo., for their helpful aid in carrying on the field work connected with the project. The interest and enterprise of Dr. F. H. H. Roberts, Jr., initiated the investigation, and his many courtesies have made the Lindenmeier Camp a pleasant memory.

GENERAL GEOLOGY OF THE LINDENMEIER SITE AND ADJACENT REGIONS

GENERAL STATEMENT

The Lindenmeier site is located in an area of complex physiographic expression, immediately east of the Colorado Front Range, and on the break in slope between the High Plains and the Colorado Piedmont (fig. 1). The little valley which contains the site owes its unique topography and availability for the accumulation and preservation of cultural remains to circumstances which can be understood only if the character and origin of these major physiographic divisions are explained.

THE TERTIARY BEDS OF THE HIGH PLAINS

Following the uplift of the Colorado Front Range in the post-Cretaceous period of disturbance, streams flowing from the newly risen mountains reduced the border of the mountains to a smooth plain and thereafter spread a mantle of alluvium eastward over a broad piedmont area. This alluviation with intervening periods of erosion continued through much of Tertiary time. In the region studied, the great apron of Tertiary alluvium forms the High Plains and consists of the Brule tuff-clay (Oligocene), and a body of more or less consolidated sand and gravel, divided into two formations: the Arikaree (Miocene) and the Ogallala (Pliocene). These three formations are separated from one another and from the underlying pre-Tertiary rocks by unconformities. As originally laid down, the Tertiary formations lapped on the lower portions of the present mountain area. Erosion has, however, almost completely stripped the mountains of this mantle of detritus, which persists only as small isolated remnants within the mountain area. Only to the west of Cheyenne, Wyo., do the High Plains and the Tertiary cover rocks now extend as far as the mountain front, in the well-known "gangplank," by which the Union Pacific Railroad reaches the core of the mountains on an easy grade.

Field work indicates that the High Plains surface of southern Wyoming is in part erosional and in part depositional. A restoration of the High Plains surface in the vicinity of Cheyenne shows that it was once a featureless plain, sloping gently eastward at 50 to 100 feet per mile. Streams have now entrenched themselves on this surface so that the original plain is represented only by tabular, eastward-sloping interstream areas. Because of the scant rainfall and the pervious character of the underlying Tertiary Arikaree and Ogallala formations, the streams of the High Plains are mostly intermittent, as shown in figure 1. Only a few of these intermittent streams have succeeded in cutting through the pervious beds to the ground-water table, held up by the underlying impervious Brule tuff-clay. Without this permanent ground-water supply the streams cannot maintain a perennial flow. Nearer the mountains, where the rainfall is greater, the streams have been able to tap the ground-water flow and on this account have been able to excavate great basins from the original High Plains. With the incision of the South Platte, and also its companion stream, the Arkansas River, far to the south, many tributaries attained perennial flow. The Colorado Piedmont was, because of the process thus initiated, excavated as a lowland below the High Plains surface.

CHARACTER OF THE COLORADO PIEDMONT

During the excavation of the Colorado Piedmont, pauses in the downcutting of the Cache la Poudre-South Platte and their tributaries led to the development of a series of gravel-capped erosion surfaces, or pediments. Each surface bevels the underlying rock and slopes gently toward the Cache la Poudre-South Platte Rivers and, when followed downstream, becomes a narrow shelf or terrace. This step-like succession of pediments lies between the mountains on the west and the escarpments of the High Plains to the north and east. During this long period of stream excavation and pediment formation, a complicated series of drainage changes has taken place along both the major and minor streams. The courses of many of the minor streams have become adjusted to the north-south structure of the Cretaceous sandstones and shales of the Piedmont area. The northern tributaries of the Cache la Poudre-South Platte Rivers have worked headward, capturing eastward-flowing streams and diverting them (fig. 1). Furthermore, these tributaries, because of their steeper gradient and greater activity, have pushed back the more or less well-defined scarp which forms the boundary between the Colorado Piedmont and the High Plains.

The topography of the scarp between the Colorado Piedmont and the High Plains has been accentuated by ground-water sapping whereever the spring zone, which marks the perched ground-water table along the upper surface of the impervious Brule formation, has been exposed by the headward erosion of small streams. Because of the location of the Lindenmeier Valley along a portion of this scarp, far from the main drainage streams, the Lindenmeier Valley has been preserved as an unusual topographic feature and archeological site (pl. 1).

ROCKS NEAR THE LINDENMEIER SITE

In the vicinity of the Lindenmeier Valley the rocks exposed in the escarpment consist of the Brule and Arikaree formations, which are here unusually thick and separated by an inconspicuous unconformity. The base of the Brule formation is a coarse conglomerate, which lies in channels on the pre-Tertiary formations. The conglomerate, 5 to 50 feet thick, is a stream-laid deposit which is overlain by clay and tuff having an estimated thickness of 350 to 400 feet. The color of the lower tuffaceous beds ranges from a drab yellow to a reddish buff, and the color of the upper tuff beds is white or slightly pink. The upper tuff is massive, almost without lamination or other evidence of the method of deposition.

Overlying the Brule formation is the Arikaree, which consists of poorly cemented arkosic sand and gravel. The gravel is composed primarily of angular to subrounded fragments of crystalline rock, and pieces of quartz and feldspar. From place to place the thickness of the Arikaree formation varies because of the irregularities of the underlying unconformable contact and of the beveling by erosion of the original upper surface of the formation during the development of the present High Plains. Near the Lindenmeier site there is a remaining uneroded thickness of at least 320 feet.

It is evident from the highly irregular bedding of the Arikaree formation that it was deposited in the channels of streams which during times of flood worked and reworked the material so that nearly all the finer debris was carried downstream and out of the area. The cement of this conglomerate is calcareous, and frequently the interstitial spaces between the small fragments of detritus may form a single calcite crystal. On weathering, the more firmly cemented beds tend to form small cliffs and in places overhanging rock shelters of small size.

SPRINGS AND THEIR SIGNIFICANCE

At and near the contact of the pervious Arikaree and the underlying impervious Brule formation, ground water emerges in a spring zone. Springs along this contact are divisible into two types: 1, definite flows of water, issuing at one or more places, and 2, large swampy areas. The point of issue is usually immediately below the Arikaree-Brule contact, and it appears that the water circulates in, and may be more or less confined to, a single point of issue by joints in the upper part of the Brule. Such a condition is well exemplified in a spring area about 6 miles west of the Lindenmeier site. At this locality, which is now dissected by deep gulches, the joints in the Brule formation are colored by limonite and have obviously served as channels of flow when the spring issued at an altitude somewhat higher than at present. The Brule has a further characteristic in that the fine pores of the tuff will transmit water by capillarity. Thus, water circulating in the joints spreads into the upper part of the formation and, where the overlying Arikaree formation has been removed, may emerge at the surface over a large area.

Whether the ground water emerges in a definite opening or over a large area as a swamp seems to depend on the local topography. If the area has been gullied, the water finds its way to the surface through a joint in the Brule and makes a definite point of issue, or spring. Such a spring is the one below the Lindenmeier Camp, in

the gully at the Lindenmeier site (pl. 2, fig. 1). In smoother topography, however, the water is brought to the surface by capillarity, and there broad swampy meadows develop. On Spottlewood Creek, sec. 19, T. 12 N., R. 68 W., there is such a meadow (pl. 2, fig. 2), and in sections 21 and 28 of the same township there is a broad meadow of about 30 acres.

Brennigan Spring, in section 30 of the same township, about 2.5 miles by road from the Lindenmeier site, illustrates both types of emergence of water. Here water pours from definite openings into the adjacent gully to form a small stream. Also, there are areas of a few square feet to as much as an acre, where water seeps to the surface. Swampy ground with a vegetation largely of sedge exists on flat places and also on hillsides with slopes as high as 15 to 20 degrees. A test pit showed, above the white tuff of this swampy tract, about 3 feet of dark earth, containing plant remains and formless humus.

Both the springs and swampy areas are of great economic importance in this region, where most of the land is utilized for grazing purposes. In this semiarid climate, with an average rainfall of about 16 to 20 inches (Martin, 1930), little unirrigated land is tilled. Dry farming is too precarious an occupation to be generally successful. Grazing is the dominant industry, especially in the areas where springs and swampy meadows dot the short grass plains with bovine oases of succulent food and drink. Range cattle limit their grazing according to distance from the springs, to which they can easily return. The Lindenmeier site lies almost surrounded by the winter range of the great Warren Livestock Co., whose sheep are lambed each spring on the green grass of the swampy meadows.

CLIMATE AND ITS INFLUENCE

Although the mean rainfall in the country immediately adjacent to the Lindenmeier site is estimated at from 16 to 20 inches, its effectiveness is limited because of the high rate of evaporation, the permeability of the surface rock and soil zones, and the irregular torrential character of the precipitation. At present this region supports a general vegetative cover of grama grass and mountain sage. Climatic fluctuations of the past may have radically altered the character of this cover. Evidences of such vegetative shifts may be found throughout the Great Plains. For example, stumps of a now extinct coniferous forest are reported along the valley of the Niobrara River in Nebraska (Aughey, 1876, p. 266), and even at the Lindenmeier site the last fringe remnant of an extension of the mountain forest onto

the plains was removed by the early settlers and has been unable to readvance over the ground lost through human destruction. Apparently the last climatic shift has been a trend toward greater aridity. If, on the other hand, a climatic swing toward more humid conditions be imagined, there would be an advance of the more humid plant associations into the present dry areas. Reconstructing the climatic conditions when glaciers occupied the mountain valleys, we should find a cooler, more humid climate, with consequent decreased evaporation. However, the region adjacent to the mountain front would be subjected to cold, drying winds, which blew across the mountains from west to east. Descending as cold winds from the mountains, they would be warmed and become drying winds in the plains region. Thus, whereas there might be expected a more humid climate with precipitation rising, in the vicinity of the Lindenmeier site, to twice the present amount, or to 40 inches, it would not follow that the vegetative cover would be a heavy forest such as one would normally expect in areas of similar precipitation in the Mississippi and Ohio Valleys. It is the writers' belief that along the mountain front there were, even in late Pleistocene time, extensive grasslands, with scattered coniferous parklike forests—a region suitable for browsing and grazing animals. Far from the major streams, which maintained a perennial flow, springs and water holes were the only sure water supplies and therefore attracted animals. In dry periods, particularly, the more extensive areas of swampy land proved as attractive then as now. Sheltered valleys such as the Lindenmeier, which contained a swampy area with springs and succulent grasses, were favorable for the congregation of animals and suitable for a camp of men who lived by hunting.

Considering this environment of the past with that of the present, it is necessary to reconstruct the many changes which have taken place since the valley was inhabited. By means of a careful and detailed study of the site itself and its relation to the regional changes which have taken place since the development of the culture layer, some concept may be gained as to the antiquity of the human artifacts.

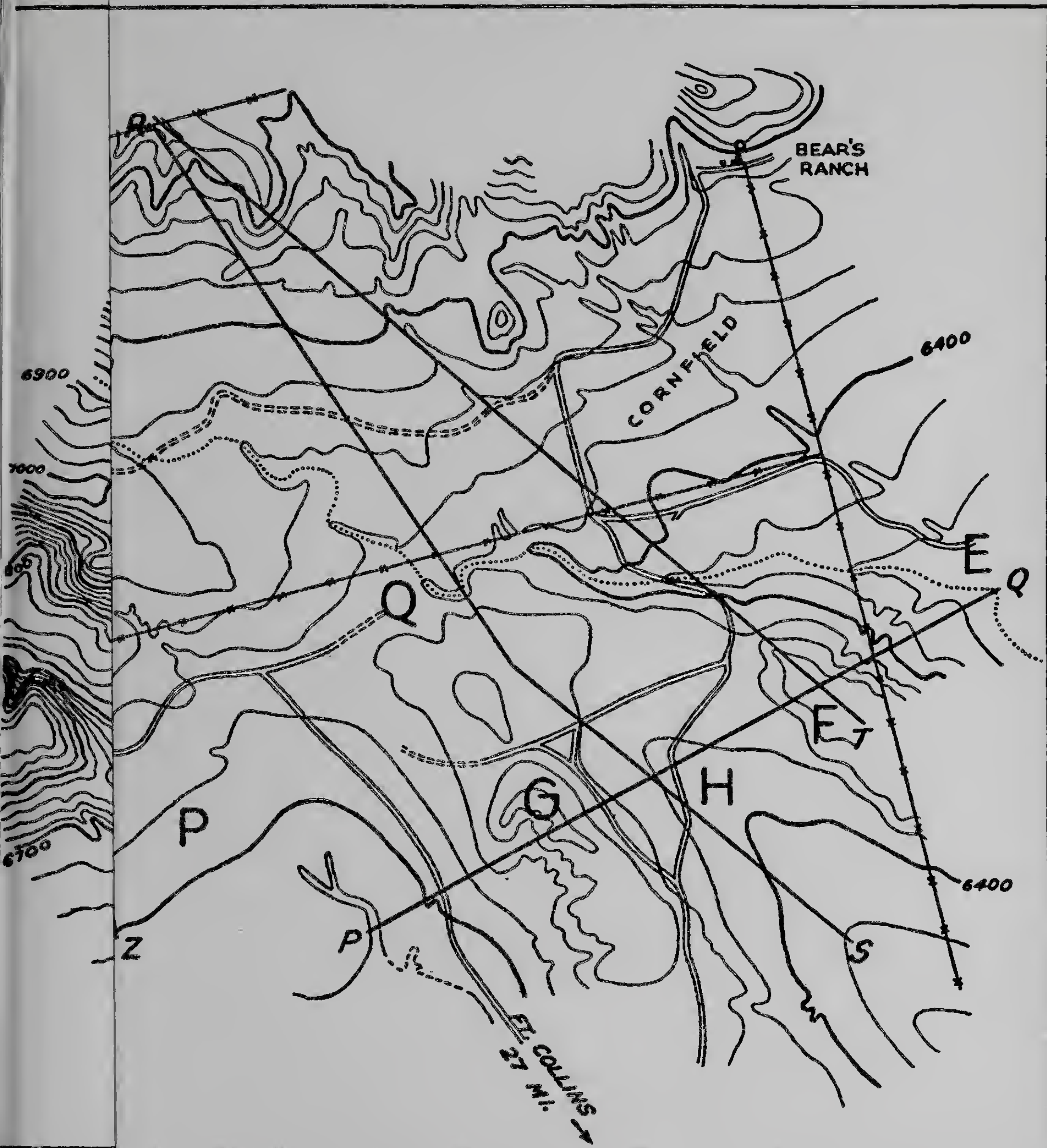
THE CULTURE LAYER AND ITS LOCAL SETTING

The extent of the culture layer at the Lindenmeier site and its relation to the local topography have been developed by painstaking excavation. The facts lead inevitably to the conclusion that the culture layer was formed under local topographic conditions which no longer exist, and it must, therefore, have considerable antiquity.

A brief review of the results of excavation will make clear the local setting in which the culture is found and will serve as an introduction to those peculiarities of the topography which furnish evidence of the complicated chain of events that led to the formation and preservation of the culture layer. The intricate history of the drainage changes, piracies, periods of erosion and alluviation of the isolated Lindenmeier Valley will be first reviewed. Thereafter the chronological sequence at the Lindenmeier site can be correlated with the contemporary events of the surrounding area.

The culture layer at the Lindenmeier site, as described by Roberts (1935, 1936, and 1937), is a brownish black earth that ranges in thickness from a mere film to 2 feet. It crops out along the southern rim of the Lindenmeier Valley and slopes northward to the relatively recent arroyo. As exposed by trenches and test pits, it extends over a large area between letters S and C on the map (fig. 2). In the admirable sections by Roberts (1936, fig. 1) the position of the culture layer on a slightly irregular floor of the Brule formation is shown. Its dark color is in strong contrast to the white color of the floor. The culture layer is a sandy clay containing scattered pebbles, secondarily derived from the Arikaree. It is overlain by a rubble consisting of more or less rounded fragments of Brule tuff, but containing also fragments of feldspar, quartz, and various crystalline rocks, obviously derived from the conglomerates of the Arikaree. This rubble increases in thickness from south to north, toward the axis of the valley, and at the arroyo is 12 to 14 feet thick, as shown at 1 in profile UV, figure 3. The unequal sizes of the fragments, the irregular bedding and the irregular lenses of this rubble, which dip gently northward with the slope of the surface, all testify to its origin as a slope wash produced by the ephemeral run-off from a hill to the south. In the area where excavations have been made, there is no longer a hill to the south. One must suppose that the hill from which this rubble was derived once existed and that it has since disappeared. Furthermore, the culture layer was formed under a set of conditions during which this suppositious hill furnished little coarse debris, and thereafter conditions changed so that the run-off of rains brought in the rubble.

Not only must these facts be explained, but further, the area north of the gully has as yet yielded no artifacts. If one searches the north banks of the gully, he finds no culture layer. On the Brule tuff, there rests an alluvium, consisting of fairly thin-bedded gravel, composed of fragments of crystalline rock—all obviously reworked from the Arikaree, as shown at 2 in profile UV, figure 3. There are nu-


BEAR'S
RANCH
CORNFIELD
6400
6900
7000
6700
6400
Q
E
Q
F
G
H
P
P
Z
S
FT. COLLINS
27 MI.

igure 3.

A brief review of the results of excavation will make clear the local setting in which the culture is found and will serve as an introduction to those peculiarities of the topography which furnish evidence of the complicated chain of events that led to the formation and preservation of the culture layer. The intricate history of the drainage changes, piracies, periods of erosion and alluviation of the isolated Lindenmeier Valley will be first reviewed. Thereafter the chronological sequence at the Lindenmeier site can be correlated with the contemporary events of the surrounding area.

The culture layer at the Lindenmeier site, as described by Roberts (1935, 1936, and 1937), is a brownish black earth that ranges in thickness from a mere film to 2 feet. It crops out along the southern rim of the Lindenmeier Valley and slopes northward to the relatively recent arroyo. As exposed by trenches and test pits, it extends over a large area between letters S and C on the map (fig. 2). In the admirable sections by Roberts (1936, fig. 1) the position of the culture layer on a slightly irregular floor of the Brule formation is shown. Its dark color is in strong contrast to the white color of the floor. The culture layer is a sandy clay containing scattered pebbles, secondarily derived from the Arikaree. It is overlain by a rubble consisting of more or less rounded fragments of Brule tuff, but containing also fragments of feldspar, quartz, and various crystalline rocks, obviously derived from the conglomerates of the Arikaree. This rubble increases in thickness from south to north, toward the axis of the valley, and at the arroyo is 12 to 14 feet thick, as shown at 1 in profile UV, figure 3. The unequal sizes of the fragments, the irregular bedding and the irregular lenses of this rubble, which dip gently northward with the slope of the surface, all testify to its origin as a slope wash produced by the ephemeral run-off from a hill to the south. In the area where excavations have been made, there is no longer a hill to the south. One must suppose that the hill from which this rubble was derived once existed and that it has since disappeared. Furthermore, the culture layer was formed under a set of conditions during which this suppositious hill furnished little coarse debris, and thereafter conditions changed so that the run-off of rains brought in the rubble.

Not only must these facts be explained, but further, the area north of the gully has as yet yielded no artifacts. If one searches the north banks of the gully, he finds no culture layer. On the Brule tuff, there rests an alluvium, consisting of fairly thin-bedded gravel, composed of fragments of crystalline rock—all obviously reworked from the Arikaree, as shown at 2 in profile UV, figure 3. There are nu-

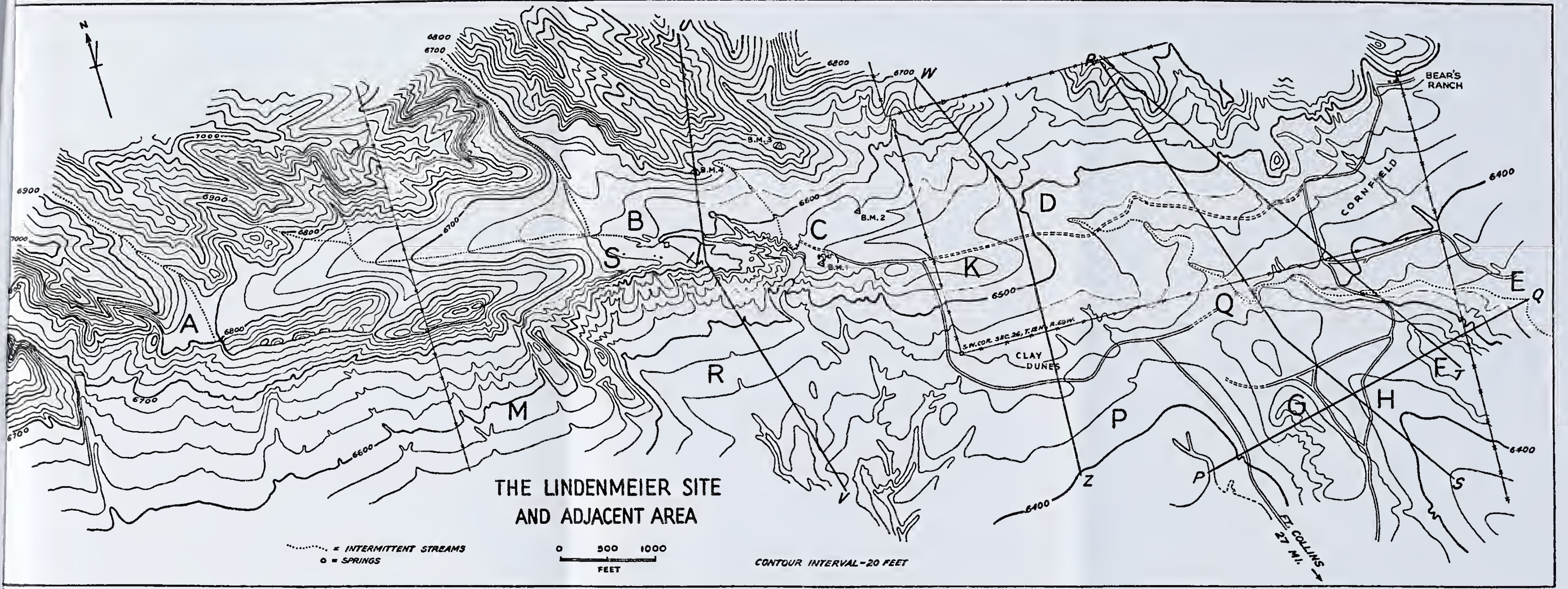


Fig. 2.—Topographic map of the Lindenmeier Valley. Letters indicate topographic features discussed in text and profiles shown in figure 3.

merous bands of dark soil, similar to the soil now underlying the grass roots at the top of the bank. It is obvious that this material was laid down rather slowly by ephemeral streams which had their origin in the areas of the outcrop of the Arikaree to the north and west. At one locality this same gravelly alluvium rests unconformably on a rubble of Brule fragments, similar to that above the culture layer. The gravelly alluvium thus appears to be not only different in origin, but also younger than the culture layer and its overlying rubble.

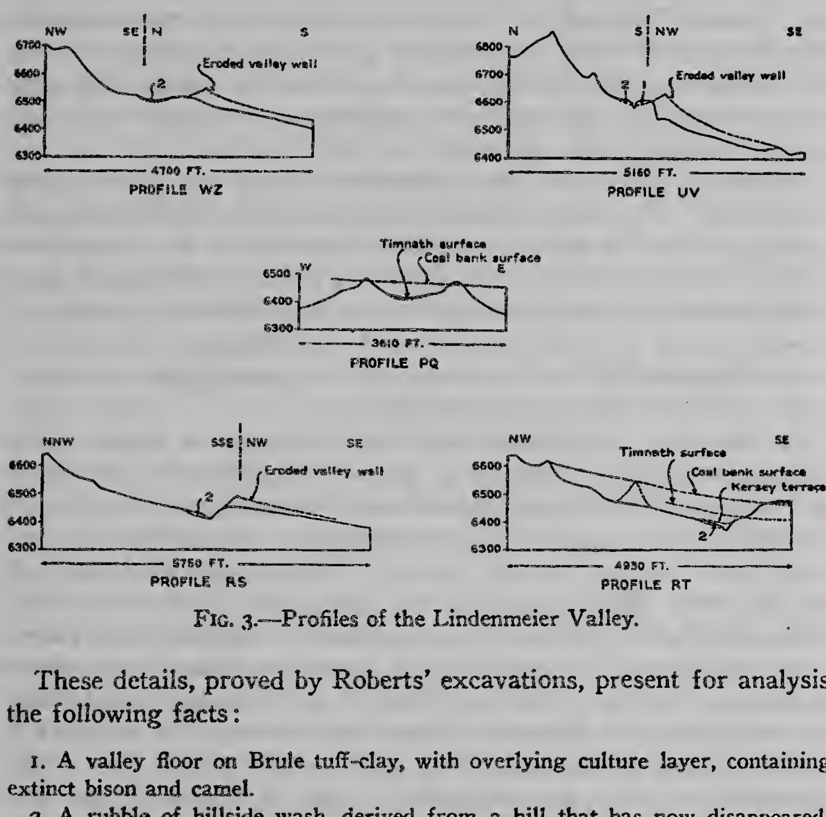


FIG. 3.—Profiles of the Lindenmeier Valley.

These details, proved by Roberts' excavations, present for analysis the following facts:

1. A valley floor on Brule tuff-clay, with overlying culture layer, containing extinct bison and camel.
2. A rubble of hillside wash, derived from a hill that has now disappeared.
3. A gravelly alluvium, free of cultural remains, which is derived from the west and north and is younger than the foregoing materials.

The history of the Lindenmeier Valley, thus recorded, is unusual. The form of the valley and its topographic details provide, however, a coordinated physiographic history into which these somewhat anomolous facts fit. The detailed topography of the valley becomes critical and must be examined at considerable length.

THE LINDENMEIER VALLEY

TOPOGRAPHY

The Lindenmeier Valley is shown in figure 2 and is also illustrated in the photograph, plate 1. It lies in the present drainage of Boxelder Creek, whose minor tributaries are in a continuous contest for drainage area. It lies also on the edge of the drainage basin of Spottlewood Creek, whose tributaries at one time probably drained the area. In each period of the lowering of grades in the stages of erosion in the Colorado Piedmont, the contest for drainage area was accentuated. Piracies occurred, and one tributary gained the advantage of lower gradient and gained drainage area from the other. At the next stage another tributary had the lower gradient and with this advantage gained territory at the expense of the other.

Immediately north of the Lindenmeier Valley the gravel-capped ridges have a common slope to the southeast. Once this was a smooth plain, graded to the South Platte River, when its bed lay at elevations somewhat more than 200 feet above the grade of the present river at its junction with the Cache la Poudre. This episode in topographic development is the Spottlewood stage,[1] when the whole of the Colorado Piedmont consisted of a single smooth graded plain cut by the Cache la Poudre River and its tributaries.

In the next, or Coalbank stage (see p. 22), the South Platte River lowered its grade about 50 feet at its junction with the Cache la Poudre, and the topography of the Piedmont area became more accentuated. The aspect of the escarpment at the Lindenmeier site was much different from the present. The sloping ridges north of the site were outlined by shallow gulches which drained southeast into a broad plain, whose existing remnants are the flat-topped ridges G and F, figure 2. These ridges are capped by coarse gravel which lies unconformably on the underlying Brule formation and further to the southeast on Cretaceous shale. As shown by the profiles RT and PQ, figure 3, this plain lay 75 feet above the present floor of the Lindenmeier Valley, between points D and E, and about 150 feet above the grade of the present streams in the plain P, west of the ridge G (fig. 2). Remnants of this surface are not detectable in the

[1] The terms "Spottlewood," "Coalbank," and "Timnath," are defined on pages 21 to 24. They have been introduced by Ray as designations of the topographic surfaces or pediments of the synchronous gravel found on these surfaces, and of the time intervals involved in the production of these surfaces. "Pleasant Valley," "Kersey," and "Kuner" are also introduced as designations of three alluvial terraces, the gravels that compose them, and the corresponding time intervals.

upper end of the Lindenmeier Valley. It seems probable, however, that the existing ridges were outlined by gulches somewhat shallower than those of the present. The Lindenmeier Valley may have been already formed and may also have drained southeastward into the broad, smooth plain represented by the ridges G and F.

As the Coalbank surface lay at considerably higher elevations than the Arikaree-Brule contact, the valleys north and west of points G and F must have been dry. Ground water may have emerged to form broad swampy tracts in the plains represented by the ridges G and F, but no tangible evidence of such a condition is preserved.

In the next, or Timnath stage (page 23), the gradient of the South Platte River was lowered some 70 feet, so that at the junction of the Cache la Poudre it was about 100 feet higher than at present. The streams of the Lindenmeier Valley area were again incised. In the lower part of the valley the drainage was still southeasterly, and most of the area drained through the broad valley at point H, between the two ridges G and F. This valley, as shown in the profile RS, figure 3, lay 50 to 60 feet above the present floor of the Lindenmeier Valley. As shown in profile PQ, it lay at about the same altitude above the plain P, west of ridge G.

At this stage, it seems likely that the upper part of the Lindenmeier Valley, points A-C, was carved into almost its present form. As a well-developed valley with a general course slightly south of east, it may have drained into a broad valley that crossed the southern boundary of the present valley between the points K and Q, in figure 2. There is no proof, however, that it may not have been a tributary of the broad valley H.

The next lowering of grades was substantial, as the South Platte River was cut to a level below its present grade, or a total downward incision of more than 100 feet. This post-Timnath deepening of grade was followed by a refilling of the valley to a height of more than 50 feet above the present grade near the junction of the Cache la Poudre and South Platte Rivers, the Pleasant Valley stage. The river again cut down to, or below, its present grade, and refilled its valley to a height 30 to 40 feet above its grade, the Kersey stage. These events on the main stream were inadequately reflected on the tributaries. The post-Timnath and post-Pleasant Valley periods of cutting are merged into one period of downcutting. Even the period of filling of the main valleys, so well marked by the Kersey terrace, is inadequately shown. The Kersey terrace, when traced up the minor streams, particularly the Boxelder drainage, becomes lower, and the gravel decreases in thickness. Instead of a terrace composed of gravel

and representing a downcutting of the stream below the present grade, followed by a refill to a grade 30 to 40 feet above that of the present, the minor streams have a terrace consisting of a platform cut on bedrock, with a thin gravel cap that lies 10 to 20 feet above the stream grade. The terrace in the minor streams represents a single downcutting and widening of the valley. The process, however, was continuous throughout the post-Timnath period of cutting. The time of deposition of the Pleasant Valley and the time of the post-Pleasant Valley period of cutting are both included in the time of formation of the terrace whose completion corresponds with the end of the Kersey period of deposition.

In the post-Timnath to Kersey time interval, the Lindenmeier Valley took its existing form. Stream piracies occurred. An eastern tributary of Boxelder Creek, known as Sand Creek, gained the Lindenmeier Valley by headward erosion into the area D-E, figure 2, cutting into and diverting the drainage of the valley that formerly led into the existing dry valley, H. This newly formed valley in the area D-E also gained the upper Lindenmeier Valley by capturing its drainage at some point between C and D. Thus, all the area became drained on a more easterly course, and the Lindenmeier Valley took its present form and was widened to its present size. At a somewhat later period a tributary of Boxelder Creek, by way of another tributary that is also called Sand Creek, cut a deep gulch west of point A and thus beheaded the Lindenmeier Valley. The beheading of the valley is well shown in the photograph, plate 1.

The development of these piracies seems to represent a remarkable series of events. To them we owe the peculiarities of form of the Lindenmeier Valley and the preservation of the culture layer. The general reasons for the piracies have already been stated, but the particular reasons for these piracies and for the times at which they occurred are not wholly clear. At least two factors were important. The tributaries of Boxelder Creek flow from the escarpment southward, and cross two sets of resistant beds. The outcrop of Cretaceous sandstones swings from the general north-northwest trend west of Fort Collins to a general east-west trend near Round Butte, about 4.5 miles south of the valley and site. Near and north of this locality the basal conglomerate of the Brule formation crops out. Thus each tributary of Boxelder Creek encounters resistance to downcutting by two resistant formations, the Cretaceous sandstones and the basal Brule. As each tributary encounters the most resistant of the Cretaceous beds at a slightly different level and as the basal conglomerate of the Tertiary is irregularly cemented, the factors of

resistance in downcutting operate on different streams at irregular intervals throughout any one period of downcutting. First one tributary is held to a higher gradient while another is able to cut downward and thus gain advantage at the headwaters. In the next interval of time, the other tributary may have the advantage.

The factor of ground water in piracy is too little considered, but its effects in an area such as this, where a strong spring zone exists at the Arikaree-Brule contact, cannot be disregarded. These springs are powerful agents in erosion because the emergent water dissolves the cement of the Arikaree and reduces the rock to gravel. It also softens the Brule tuff into a slippery claylike mass. Obviously an ephemeral stream reinforced by a spring is more powerful in extending its drainage than a similar stream without such help. In the beginning of the history of the area, up to the periods of the piracies, the grades of streams in the area of the Lindenmeier Valley were above the spring horizon, and the effects of the emergent water were negligible. Farther to the south, the springs may have played a large role in the planation that occurred. Furthermore, the piracy from the east, which brought the Lindenmeier Valley into the drainage of Sand Creek in the post-Timnath period of downcutting, may have been largely brought about by the diversion of ground water in that direction by reason of the extension of Spottlewood Creek.

The period of piracy of post-Timnath time produced the Lindenmeier Valley, and, by the close of Kersey time, it was broadened and reduced to its present grade. This valley with its almost east-west course, its low rim to the south and its swampy floor, slightly incised below the Arikaree-Brule contact, was a suitable camping and hunting ground for the Folsom people.

Modifications of the valley were, however, in progress. Streams heading in the ridge on the south flank of the valley have a direct course to Boxelder Creek and by headward erosion produced the plain M-R-P, figure 2. These streams by headward erosion reduced the ridge or southern wall of the Lindenmeier Valley at two levels of erosion. On the west the streams cut the plain M nearly 75 feet higher than the plain R-P on the east. This plain appears to have been cut at the Timnath stage. The lower plain, however, reached its present smooth grade in the Kersey stage and downstream merges into the 20-foot terrace of the streams. The form of the upper portion of the valley and the thinning of the southern wall by this process of headward sapping is shown in profile WZ, figure 3.

It is obvious that the streams on the grade of the plain R-P (fig. 2) were most successful in reducing the valley wall, which became a low,

rounded ridge. Even today this ridge is being reduced, and the former floor of the Lindenmeier Valley crops out as a dark layer on the white Brule tuff-clay from points S through C to K, except where protected by blocks of Arikaree derived from slopes that have now disappeared. This relation is brought out in profiles WZ and UV (fig. 3).

The lowering of grades and abandonment of the Kersey terrace on the South Platte River was followed by a period of filling to a level 20 feet above grade to form the Kuner terrace. Since that time the river has cut to or below its present grade and formed the existing wide flood plain. These events are imperfectly preserved on the tributary streams. The Kuner terrace cannot be followed up the minor tributaries and appears to merge with their flood plains. In the area south of the Lindenmeier site, on the plain R-P, there is only a set of deep ravines to represent the post-Kersey series of events on the main stream.

Furthermore, the continued development of the plain R-P, figure 2, and the continued sapping of the south wall of the valley led to the loss of the ground water and finally to piracy of the surface drainage. During the period of occupation, as shown by excavation, the south slope of the valley and presumably a large part of the valley floor was covered by dark earth similar to material now underlying the spring meadows of nearby localities. Thus, the conclusion is forced that the valley floor was a wet and springy meadow, which stood at elevations 50 to 75 feet higher than the plain R-P, immediately to the south. As the plain advanced northward by the erosion of the dividing ridge, the hydraulic gradient between the valley and the plain became steeper. Eventually the ground water was drained out through one of the joints in the Brule. The diffused spring or wet meadow was converted into a definite spring opening at a lower level.

With the drying of the valley floor, hillside wash covered and preserved the old meadow soil and thus entombed the relics of the Folsom peoples. Furthermore, the valley was no longer as attractive to man and beast, whose activities would be transferred to the plain R-P. Thus, the rubble which overlies the culture layer is barren of fossil bone and almost barren of the relics of man.

The formerly moist Lindenmeier Valley thus dried up by groundwater piracy was drained by an ephemeral stream. This stream enfeebled by the piracy at A, was attacked in its lower portions by headward erosion in post-Kersey time. In the area E-D, figure 2, especially near the cornfield of Bear's Ranch, the original valley floor was

largely destroyed and persists only as a series of terrace remnants. This gully extended upstream past the site, a little past the point B, and was later filled by the alluvial deposit barren of cultural remains, which has already been described. In turn, this deposit has been eroded by the gully extending from B to C, figure 2.

The date of these events is unknown. Many valleys of the southwestern United States were eroded, filled, and again eroded within the period of Pueblo occupation (Bryan, 1926). It may be that these events lie within this very recent period of alternate erosion and alluviation.

The most striking event of relatively recent time is the formation of the gulch extending from the plain R-P to B, figure 2. This gulch, according to the local residents, antedates occupation of the area by the white man. It is about 70 feet deep near the point C, and is being actively deepened, widened, and advanced headward at the present time. The piracy of the surface drainage of the Lindenmeier Valley by this gulch is a logical aftermath of the piracy of the ground water. The existence of a spring within this gulch leads to softening and weathering of the Brule, to the trampling of the surface by animals, and to active wind erosion, by which small tuff-clay dunes were built (fig. 2), and to active gullying. For these reasons the original hill in the areas S to C was carried away by the ephemeral streams forming the plain R-P. Eventually that ridge was so lowered that the surface drainage poured over the ridge to form the beginning of the gully. As this gully, or gulch, retreats, the spring also retreats to the north and west, softening the Brule and preparing the way for active erosion during the periods of storm, when water pours into the gully from rains.

CONCLUSION

The successive stages during which the grades of streams in the region were lowered promoted and also timed the successive piracies by which the Lindenmeier Valley gained its present topographic form.

Here, in the interval when the main rivers were forming the Kersey terrace, was a relatively sheltered valley with water and grass, attractive to animals and an ideal site for a hunting camp. No doubt there were other such sites in the region, but at no other yet found has later erosion been so feeble as to preserve, and yet so active as to expose, the deposits of that time.

PEDIMENTS AND TERRACES OF THE COLORADO PIEDMONT

GENERAL STATEMENT

The northern part of the Colorado Piedmont was developed as a great lowland below the grade of the High Plains surface in several successive stages of erosion. Each stage was begun by a lowering of grade of the main river, followed by a stabilization of grade or by alluviation. Into this sequence of events the detailed story of the Lindenmeier Valley fits. By a consideration of the history of this larger area, the significant event at the site, that is, the formation of the culture layer, may be connected with an event having a large geographic range.

The first period of incision of streams below the original grades led to the development of a broad lowland in almost the same position, and having nearly the same area, as the present Colorado Piedmont. Within this lowland the tributaries of the Cache la Poudre-South Platte Rivers shifted from one position to another over the broad, sloping plains with comparative ease (fig. 4). Obviously the development of so large and so perfect a surface, even in rocks relatively as easily graded as the Tertiary and Cretaceous rocks of this area, must have consumed a considerable time.

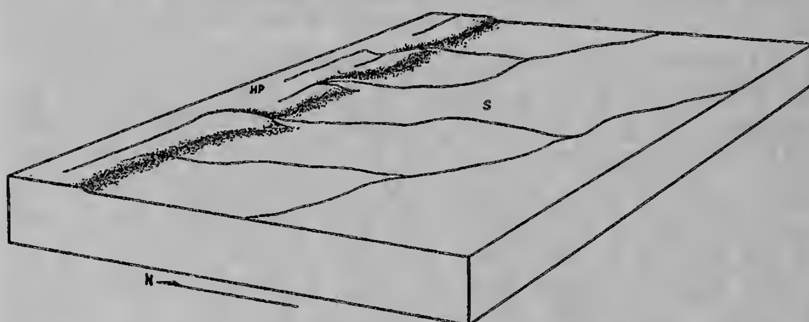


FIG. 4.—Generalized block diagram showing development of the Spottlewood pediment below the High Plains surface in the northern Colorado Piedmont.

This lowering of the stream grades within the Colorado Piedmont took place in post-Pliocene time and occupied most of the early and middle Pleistocene. It seems probable that each lowering of the grades, by which the pediments were formed, was due to uplift of both the mountain area and the western portion of the plains, as has been established for the similar sequence of events in Montana (Alden, 1932). On the other hand, during the Pleistocene there existed a

fluctuating climate, the effect of which on the grades of streams (Johnson, 1901) is as yet imperfectly understood.

This period of dissection was relatively long and efficient. After each incision of the streams there was stabilization of grades, and broad surfaces of erosion (pediments) were developed, which in places bevel the underlying deformed bedrock.[2] Each surface was more or less covered by a thin mantle of gravel—the channel deposits of the streams to whose lateral planations much of the development of the surfaces is due.

The last of the pediments was strongly dissected in the "canyon-cutting cycle," when the major streams cut to, or below, present stream grades. There are alluvial terraces younger than this period of canyon-cutting, and their distribution is restricted to narrow belts in the existing stream valleys. Each of these terraces records a filling of the valley and a reexcavation to, or below, the present grades of the major streams.

The gravel-capped pediments were formed in the earlier part of the Pleistocene. The terraces are, however, Wisconsin and later in age, and, as will be shown, are directly related to the later stages of mountain glaciation.

SPOTTLEWOOD PEDIMENT

The oldest and highest of the pediment surfaces (fig. 4) has now been so nearly destroyed that only a few scattered remnants yet rise above the younger erosion surfaces of the area. The name "Spottlewood pediment" is given to the surface because it is preserved along the escarpment between the High Plains and the Colorado Piedmont, in the headwater area of Spottlewood Creek, near the Lindenmeier site. It also forms the upper surface of Wildhorse Tit, a well-known landmark in sec. 23, T. 10 N., R. 64 W. (see Eaton Quadrangle). Remnants of the Spottlewood pediment are gravel-capped, and the term "Spottlewood" includes both the gravel and the time interval during which the pediment was formed.

Along the High Plains escarpment, in the vicinity of the Lindenmeier site, the Spottlewood pediment is represented by numerous gravel-capped spurs that slope gently southeastward and bevel the Arikaree formation. The high hills, approximately 16 miles west of

[2] Figures 4, 5, 6, and 7 are generalized block diagrams which represent the northern portion of the Colorado Piedmont in the Livermore and Eaton topographic quadrangles and adjacent regions. These are intended to give a general pictorial history of the development of the pediment and terrace surfaces and not to furnish details of the actual development in each minor area.

Wildhorse Tit[3] are relatively large remnants of this surface. Overlying their cap of well-rounded stream gravel is a thin layer of wind-blown sand, which has at its base a layer of ventifacts. At the Lindenmeier site the Spottlewood pediment is preserved in the south-eastward-sloping, flat-topped ridges that lie to the north of the valley.

COALBANK PEDIMENT

Along the Cache la Poudre River and extending up its tributaries there are remnants of an easily recognizable pediment. On the main streams it has a grade about 50 feet below the Spottlewood pediment (fig. 5). Because it is well preserved on the high ridge 24 miles northwest of the junction of the Cache la Poudre and South Platte Rivers, it has been named the "Coalbank pediment,"[4] a term applicable to the synchronous gravel and the time interval involved.

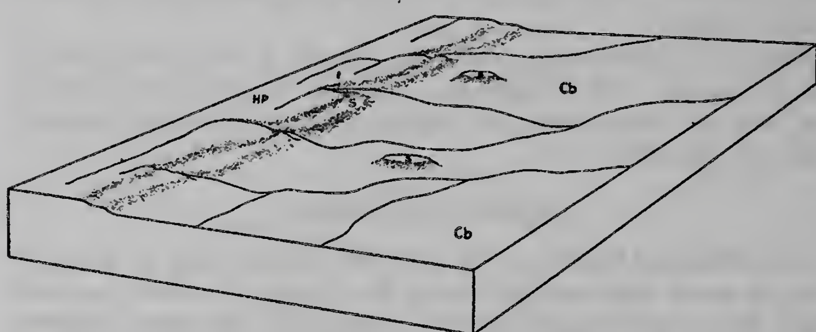


FIG. 5.—Generalized block diagram showing development of the Coalbank pediment below the Spottlewood pediment.

This surface, like the Spottlewood, bevels bedrock and is covered by a gravel cap, overlain by scattered ventifacts and wind-blown sand. It was formed during a period of stationary base level and lateral planation of streams. In the Coalbank stage the streams near the borders of the Piedmont area widened their floors into broad valleys, as shown in figure 5. However, planation did not continue long enough for the complete destruction by stream action of all the remnants of the previously formed Spottlewood pediment. These remnants, then as now, stood as hills and flat-topped ridges above the broad, sloping plains of the Coalbank surface (fig. 5). At the Lindenmeier site, as described on page 14, the Coalbank pediment is preserved in the form of two gravel-capped mesas, G and F, figure 2.

[3] These hills are 4 miles west of the railroad siding of Dover, a locality in the Eaton Quadrangle.

[4] "Coalbank" is the local name of the ridge between Lone Tree and Boxelder Creeks in the Livermore and Eaton Quadrangles.

TIMNATH PEDIMENT

A third period of stream incision, followed by planation by streams and the development of a broad valley stage in the tributaries of the main rivers, produced the Timnath pediment (fig. 6). This surface, the synchronous gravel, and the time interval are named for the village of Timnath.[5] The hills east of this village lie about 21 miles northwest of the junction of the Cache la Poudre and South Platte Rivers.

Near this junction the Timnath surface lies approximately 70 feet below the grade of the Coalbank pediment and about 80 to 100 feet above the river. Except that the areas of planation are smaller, this pediment has the same characteristics as the two older surfaces. In the vicinity of the High Plains escarpment, relatively narrow valleys

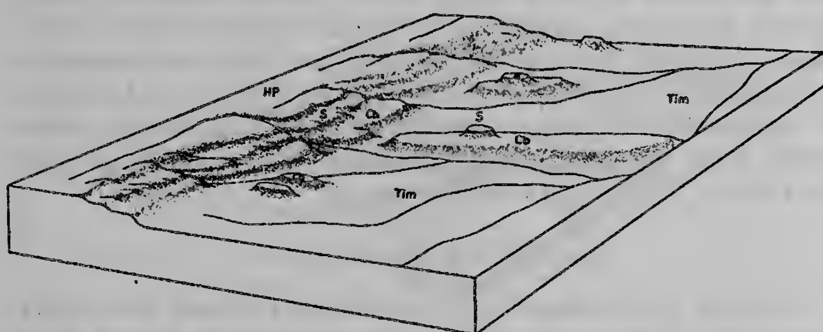


FIG. 6.—Generalized block diagram showing development of the Timnath pediment below the Coalbank pediment.

were developed, so that near the Lindenmeier site the most easily recognized remnant of the Timnath pediment is a flat-floored valley (H in fig. 2), lying between the two mesas that are, as previously stated, remnants of the Coalbank pediment.

The gradients of all the pediments steepen toward the mountain front and toward the escarpment of the High Plains. The pediment surfaces can be traced into the mountains, where they are represented by rock benches and spurs along the main drainage streams, and in a few localities by open valleys with subdued and terraced topography. Examination of the High Plains escarpment shows that the area of the Colorado Piedmont has not been much extended since the initial incision of the High Plains surface by the streams

[5] Timnath, a railroad station and village, shown on the Eaton Quadrangle, approximately 17 miles northwest of Greeley, Colo.

which cut the Spottlewood pediment. The Colorado Piedmont has been deepened and its borders diversified by newly cut canyons and gulches.

PIRACY BY THE SOUTH PLATTE RIVER

The South Platte River, above its junction with the Cache la Poudre at Greeley, has a course inconsistent with the slope of the Spottlewood and Coalbank pediments. However, the Timnath pediment is developed along the course of this stream. It appears, therefore, that at the beginning of the development of the lowland of the Colorado Piedmont, the Cache la Poudre and the part of the South Platte east of their present junction formed the main stream of the region. The upper part of the South Platte River appears to have been a tributary of the Arkansas River. In the interval of stream incision between the Coalbank and Timnath stages a tributary of the Cache la Poudre captured the waters of the large area drained by the upper part of the South Platte. This recently acquired drainage is larger and better watered than the original area, and the South Platte River has become the main stream of the region, reducing the Cache la Poudre to a tributary (fig. 1).

THE CANYON-CUTTING CYCLE

Following the development of the Timnath pediment, there was a new period of stream entrenchment. Not only were the streams of the Piedmont area deeply incised to grades below the present grades of the rivers, but great erosion occurred in the mountains. The streams of the mountain area cut canyons almost as large and as deep as their present canyons, and hence this period is known as the "canyon-cutting cycle" (Van Tuyl and Lovering, 1935). It is merely a repetition of the three preceding periods of incision, the pre-Spottlewood, pre-Coalbank, and pre-Timnath cycles. The severity of the entrenchment, both in the mountains and in the plains, is marked. Furthermore, it ushered in a new series of changes in stream gradients in which, between periods of incision, aggradation rather than planation was characteristic.

ALLUVIAL TERRACES

After the canyon-cutting cycle the main streams built up their channels with alluvium in successive intervals, separated by intervals of renewed downcutting (fig. 7). On the minor tributaries of the Piedmont area these changes are, however, not perfectly recorded.

The stages appear to have been short, and the minor tributaries were too feeble to accomplish complete gradation to the main streams at each successive change in grade.

A careful study of the valleys of the Cache la Poudre and South Platte Rivers has brought to light only a few remnants of the earliest and highest of the alluvial terraces. Later erosion has destroyed and carried downstream much of this material. Also, wind action has accumulated many dunes which so bury the areas adjacent to the rivers that remnants of terraces are concealed. The most extensive and most easily recognized terrace representing the maximum of valley filling is at the locality called Pleasant Valley, north of the confluence of the Cache la Poudre and the South Platte Rivers. The highest alluvial terrace is named for this locality, where the top of

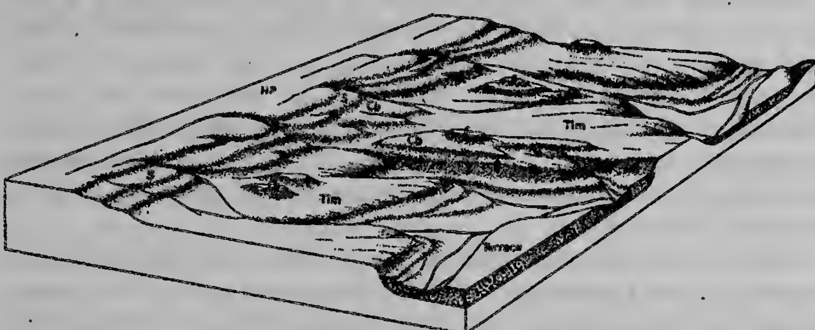


FIG. 7.—Generalized block diagram showing development of alluvial terraces in deep valleys cut into the Timnath pediment during the canyon-cutting cycle.

the terrace lies more than 50 feet above the river grade. The terrace consists mostly of sand with moderate amounts of gravel. Here, and in other localities, it is masked by wind-blown sand, and in many places merges topographically with the lower terraces. Terraces attributed to the Pleasant Valley stage may represent two periods of alluviation. The terrace remnants are so few and are so obscured that such a relation might exist without leaving easily detectable traces.

Strong stream erosion destroyed most of the alluvial fill represented by the Pleasant Valley terrace, and the main rivers once again cut down to, or below, their present grade. Deposition then began anew, and river gradients were built up to form alluvial plains now represented by a strong terrace, which is very well preserved, and forms the main agricultural area on the South Platte River. It is prominent near the village of Kersey, a railroad station, approxi-

mately 7 miles east and slightly south of Greeley, Colo. The alluvium of this terrace, as shown in numerous pits, is largely a fine-grained gravel and sand. Much of the surface of the Kersey terrace is covered by dune sand and by alluvial fans, especially on the borders away from the rivers (pl. 3, fig. 1). Its general surface lies between 25 and 30 feet above the present stream grade at the type locality. Near the valley walls the terrace surface may rise gradually to elevations of 40 to 45 feet because of accretions to the strictly river-laid fill. At places along the main streams and the tributaries the upper 2 to 12 feet of terrace gravel is deformed into an involuted and formless mass in which ventifacts may be found. This material is a characteristic warp attributable to intensive frost action in a severe and windy climate such as no longer exists.

Separated from the Kersey terrace by a well-defined scarp is the lowest recognizable terrace. At the type locality, near Kuner, a railroad station 5 miles east of Kersey (fig. 1), this terrace, to which the name "Kuner" is applied, lies about 12 feet above the river. Gravel and sand pits show that its composition is essentially the same as the older and higher Kersey terrace. In some places the surface of the Kuner terrace rises to as much as 20 feet above the level of the South Platte River.

The Kersey stage of alluviation was followed by erosion and the lowering of river grades to, or below, the present grade. The Kuner terrace represents a period of alluviation in which the river grades were not built so high as in the earlier stage. Again the rivers incised themselves and dissected the Kuner terrace. Between the Kuner terrace and the broad flood plain of the rivers no lower terraces have been detected.

MODERN FLOOD PLAIN

The flood plain of the South Platte and Cache la Poudre Rivers is broad, with a width ranging from a few hundred feet to a mile and a half. Across the surface the rivers flow in a channel which in places is braided, suggesting aggradation. The rivers, at ordinary low water, flow in channels 4 to 6 feet below the flood plain, as at Kersey, or less than a foot, as at Platteville. This variation is the result of the numerous irrigation dams which create, at moderate river stages, an artificial gradient. It is now impossible to measure the height of the lower terrace level above the natural stream grade, for one must use this artificial grade. However, the discrepancies between these grades are of small importance in the study of the higher surfaces. In spite of the dams, the river in times of flood covers the whole of the flood

plain, as attested by local residents, and thus it may be that the present artificial grade at low or medium stages is not reflected in the flood gradient, which may be identical with that existing before the dams were built.

The surface of the flood plain is not a perfect flat, but in a number of places there are small meander marks, abandoned stream channels, and gentle ridges and furrows 2 to 3 feet in height. None of these features seems to indicate the existence of a terrace younger than the Kuner, although many of them cannot be clearly interpreted. Materials composing the visible portion of the flood plain are of small size, containing none of the coarse well-rounded boulders characteristic of the higher terraces or of the river bed at the mouth of the Cache la Poudre Canyon. At many places there are thin lenses of sand and loam interbedded with equally thin beds of fine-grained gravel, composed of quartz and pink feldspar.

SUMMARY

As a result of uplift and dissection of the High Plains surface, three successive periods of incision and planation by the streams in the northern Colorado Piedmont have produced three successively lower gravel-capped pediment surfaces, cut on bedrock. Alternate incision and alluviation have produced three or perhaps four alluvial stream terraces at lower elevations. The important period of valley deepening, the canyon-cutting cycle, separates these two sequences of events and is of greatest value in the correlation of the history of the Colorado Piedmont with that of the mountains. As hereafter shown, the pediments and erosional surfaces, well developed in the soft sandstone, shale, and limestone of the Piedmont area, are now represented in the mountains by spurs on the canyon wall, which are relics of old broad valleys. The alluvial stream terraces can be traced continuously along the major streams from the Piedmont into the mountains, where each terrace ends at the moraine left by an ancient glacier. The alluvial terraces are thus directly correlative and synchronous with glacial stages.

GLACIATION OF THE CACHE LA POUDRE VALLEY

It has long been known that during the Pleistocene period the mountains of Colorado supported extensive valley glaciers. Even now small glaciers and permanent snow fields linger in sheltered cirques of the high mountains. The northernmost of these, Hallet Glacier, nestles in a cirque head on the northeast flank of Hagues

Peak, only 45 miles southwest of the Lindenmeier site and 25 miles due west of the mountain front. To the south, in similar cirques along the high crest of the Continental Divide, there are numerous ice and snow masses. Northward, and west of the area here considered, the peaks of the Colorado Front Range decrease in altitude and lie too low to support permanent snow fields under the present climatic conditions.

Although numerous descriptive studies have been made of the glaciers of Colorado and of other parts of western United States, there has been, with the exception of Blackwelder's comprehensive study (1931), little or no attempt at regional correlation of glacial stages. By the very nature of the problem, a great deal more data, both descriptive and quantitative, must be gathered before the complete picture can be brought into focus. Until that time, workers must be content with local chronologies and a correlation with continental glacial stages based on purely qualitative evidence.

General geologic thought, as summarized by Blackwelder (1931), assumes that the last advances of the valley glaciers in the Colorado mountains, and elsewhere in the Rocky Mountains, were contemporaneous with the advances of the continental glaciers in Wisconsin time. This assumption is granted by the writers and is used as one of the bases for correlation.

In the drainage basin of the Cache la Poudre River there is definite evidence for one glacial stage of pre-Wisconsin age and three glacial substages of Wisconsin age. There is reason to believe that a fourth substage, the earliest Wisconsin, occurred but left so few traces that its existence is not completely proved. Furthermore, a fifth substage is represented in this region, not by the morainal relics of glaciers, however small, but by the less prominent effects of a strong refrigeration of climate. These glacial stages will be reviewed in a chronological order, from the oldest to the youngest.

PRAIRIE DIVIDE GLACIAL STAGE

The oldest glacial deposit of the Cache la Poudre drainage forms the surface of Prairie Divide, a broad mountain flat, with an altitude of approximately 7,900 feet (T. 10 N., R. 72 W., Livermore and Home Quadrangles). Here, weathered gravel rests upon a deeply weathered glacial till. The gravel and till form a plain, so perched above the level of the present drainage that it is being eroded from all sides. Great bodies of slumped material fill valleys which have cut headward into the mass (pl. 3, fig. 2). Small patches of weathered

loess, containing calcareous concretions, or *loess kindchen,* lie within the slumped masses, below the general level of the plain, and the loess may, therefore, be younger than the till and gravel.

The till and gravel of Prairie Divide represent a widespread glaciation. Their weathered condition and their topographic position above the valleys containing the more recent glacial deposits testify to the relatively great age of this glacial stage. The locality is also far to the east of the most advanced position of the later glacial moraines, a fact which suggests a very much larger glacier than any formed in later time. This glaciation is here named the "Prairie Divide stage" and is probably correlative with the Cerro glaciation of the San Juan Mountains (Atwood and Mather, 1932).

OTHER POSSIBLE PRE-WISCONSIN GLACIATIONS

No evidence of a glacial stage comparable in size and position with the Durango stage of the San Juan Mountains (Atwood and Mather, 1932) has been discovered in the Cache la Poudre drainage basin. The Durango stage is, however, assigned somewhat doubtfully to the Iowan, here termed "Wisconsin I." Further study may indicate that the pre-Home glacial substage, to be described, is correlative with the Durango glaciation, but at present it can be suggested only as a possibility.

At several places in the Colorado Front Range, Ray has observed glacial till which is best attributed to the Durango stage. A detailed description of these deposits will appear in a forthcoming paper on the glaciation of the Southern Rocky Mountains.

THE CANYON-CUTTING CYCLE

During the long interval which separated the earlier from the Wisconsin glaciations of the Colorado Front Range, streams entrenched themselves deeply in both the mountains and the plains. This period of erosion, called the "canyon-cutting cycle" (Van Tuyl and Lovering, 1935), marks the time immediately preceding the Wisconsin glaciation. Remnants of the materials deposited by the two earlier glacial epochs were dissected during this stage. The general relationship between this period of stream entrenchment and the stages of glaciation characteristic of other mountains of the Cordilleran region appears to hold throughout this area.

The Cache la Poudre Valley within the mountains is deeply entrenched, set within an older, broader valley that is now represented by prominent rock spurs. The lower, or downstream part of the

canyon is typically unglaciated and V-shaped. The upper, or upstream part, is characterized by a U-shaped profile and also by erratics, roche moutonnée surfaces, small hanging valleys, and isolated patches of glacial debris. Transition between the two valley types occurs at Home Post Office (fig. 1), at an elevation of about 7,600 feet. Here, a terminal moraine stretches almost completely across the valley, rising about 135 feet above the level of the river, which flows through a notch between the moraine and the bedrock of the northern valley wall (pl. 4).

HOME, AND A POSSIBLE EARLIER, GLACIAL SUBSTAGE

The moraine at Home Post Office (pl. 4) presents a rounded and mature aspect. However, careful examination shows that this smooth topography is the result of a covering of wind-blown sand. On the upstream side of the moraine the cover is thicker and more effectively conceals the bouldery surface than on the downstream side. Scattered over the surface of the moraine are ventifacts, or stones that are polished, grooved, and faceted by wind-blown sand. Obviously, sand is not now moving down the valley, and one must suppose that the small dunes behind the moraine and the sand that cut the ventifacts were moved by winds that swept down the valley over the glacier. The sand was derived from the surface of the glacier and from the barren outwash plains. Such cold glacial winds moving down the valley under gravitational forces are characteristic of the valleys below existing glaciers in Alaska, where dunes are being built from sands of the outwash plains. Similar dunes are built and stones are being cut on the outwash plains of Greenland (Hobbs, 1931). In the Sierra Nevada of California, Blackwelder (1929) has described a boulder carved during the Pleistocene by wind-blown sand.

Roche moutonnée surfaces adjacent to the moraine are fresh and show glacial striae at localities that are protected by a slight covering of glacial drift or of vegetation, whereas unprotected surfaces lack polish or striations. When fully exposed to weathering at the present rate in these altitudes, the bedrock is so easily weathered that it is unable to retain the marks of glaciation for any great length of time. For the foregoing reasons, the apparent lack of glaciated surfaces related to the moraine does not necessarily imply great age. Observation throughout the Colorado Front Range indicates that glaciated surfaces, related to moraines otherwise similar, are, unless protected, preserved only on unusually durable rock.

The question has been raised whether the moraine at Home, and the glacial substage named for it (Louis L. Ray, 1938), are possibly

of pre-Wisconsin age. The subdued topography of the moraine might, as some writers hold for other localities, be attributed to long weathering of the surface during and after the retreat of the ice. One needs to guard against attempting to date glacial stages on the basis of a subdued topography of the moraines, for in this case it is not due to processes of weathering and denudation, but to wind deposition. Considering the topographic position of these moraines within the present canyons, the relatively slight degree of chemical alteration and slight compaction of the till, and the lack of deep gullying on the Home moraine, or on similar moraines in other areas of the Front Range, the writers believe that it is impossible to assign an age older than Wisconsin. General indications are, however, that these moraines were not made by the first advance of the valley glaciers in Wisconsin time, that is, the Iowan substage or Wisconsin I, but were made by the second advance of the Wisconsin time, or Wisconsin II.

Several lines of evidence point to the possibility of a pre-Home glacial substage, the terminal moraine of which, now removed by erosion, was almost coincident with the Home moraine. As shown in plate 5, figure 1, several large erratic boulders lie well above the valley floor on the south valley wall, immediately upstream from the Home moraine. Inasmuch as they lie above the reconstructed grade of the ice which built the Home moraine, it is conceivable, but highly improbable, that they were brought to position during that period of glaciation. A somewhat larger glacier, which extended perhaps as much as half a mile farther down the valley, would have had a height sufficient to have deposited the boulders in their present position. For the half mile below the Home moraine, the canyon is open and U-shaped, and is then sharply constricted into a V-shaped gorge. This narrow, winding gorge shows no signs of glaciation.

The most definite evidences for a pre-Home period of glaciation are small lateral valleys, some 250 feet or more above the present level of the valley floor (C and D in fig. 8). Compared to the lower and similar valleys at B (fig. 8) they are relatively old, as the walls are much weathered and the floors are filled with talus. These valleys were formed by streams which drained the lateral margin of a valley glacier too high to have been related to the Home moraine. These small valleys are similar in origin to the lateral channel that lies about 140 feet below (B in fig. 8). This valley has straight clean walls and is so youthful that it seems to have been deserted only yesterday by the waters which carved it. It stands at an elevation so low that it must have been cut by streams draining the lateral margin of the ice as it began to retreat from the Home moraine. It is not necessary to

postulate a long period for the formation of these little canyons, for similar straight-walled cuts in bedrock form in short periods of years along the lateral margins of the present retreating glaciers of Alaska (Louis L. Ray, 1935, pp. 304-307).

Further evidence for this postulated pre-Home glacier exists in the lower canyon in bodies of gravel which stand too high above the river to be remnants of the valley train produced by the Home glaciation (see pp. 42 and 43).

The positions of erratics near the Home moraine, the high lateral canyon, and the pre-Home valley train all seem to indicate that a valley glacier, whose terminal moraine has been completely removed, once existed. On the basis of this evidence, the writers postulate

FIG. 8.—Sketch map of the Cache la Poudre Valley at Home Post Office, showing: A, Home moraine; B, low lateral bedrock gorge; C and D, high lateral bedrock gorge; and terraces of 5 groups, numbered from youngest and lowest to oldest and highest.

a pre-Home glacial substage of Wisconsin I (Iowan) age, but they have refrained from giving it a name.

The evidence in the Cache la Poudre Canyon for this pre-Home substage is not as complete as is desirable, but in adjacent regions there is additional evidence, of which the most important may come from the region immediately south of the Rocky Mountain National Park, near Ward (Wahlstrom, 1939). Furthermore, Ray has examined the moraines of the Libbey Creek Valley in the Medicine Bow Mountains, described by W. W. Atwood, Jr. (1937).

The moraine near Libbey Lodge, which has been attributed to the Wisconsin by Atwood, has an aspect similar to the Home moraine. It is here correlated with the Home moraine and attributed to Wisconsin II. The lowest moraines in the inner valley, between Libbey Lodge and Centennial, which Atwood considers pre-Wisconsin, have a somewhat older aspect, and may be correlated with the pre-Home,

or Wisconsin I. It is possible that Atwood uses "pre-Wisconsin" in the sense of Iowan of the older terminology. Under present usage Iowan is equivalent to Wisconsin I, in which case, his correlation is equivalent to the one here given.

The Home substage of glaciation is represented by the moraine, already described, and the outwash plain, or valley train, preserved as terrace remnants approximately 90 feet high, immediately below the moraine. Small lateral channels cut as sharp boxlike canyons 15 feet wide and 20 feet deep in bedrock occur on the north side of the valley, 60 feet above the stream grade (fig. 8, B). Patches of striated and wind-polished rock occur on the flats above and on the upper parts of the walls of these little canyons. That these surfaces are yet unharmed by weathering is in itself evidence of the relatively recent date of the Home substage, which is considered to be of Wisconsin II age.

CORRAL CREEK SUBSTAGE OF GLACIATION

Following the retreat of the glaciers of the Home substage, or their possible complete disappearance, there was another glacial advance. The ice streams were relatively small and reached down to and formed moraines at elevations ranging from 9,100 to 10,100 feet in the valley of the Cache la Poudre River and its major tributaries. Instead of a single moraine, there are moraines in the tributary canyons that lie from 1,500 to 2,500 feet above the moraine at Home. The ice tongues that built these moraines descended from cirques down the valleys of Long Draw, Trap, Joe Wright, and Corral Creeks, and also in the so-called main valley of the Cache la Poudre.

The best-developed moraines lie in the valley of Corral Creek, whose name has been given to this substage (Louis L. Ray, 1938). Here the ice tongue extended approximately 4 miles from the cirque, to an altitude of 10,100 feet (pl. 5, fig. 2). The moraine stretches almost completely across the valley, except for a small notch along the south side, through which Corral Creek flows to join the Cache la Poudre River about a mile and a half downstream. Up the valley, there are small patches of glacial debris, scattered along the broad, flat valley floor, deposited during retreatal pauses of the Corral Creek glacier as it receded from the advanced position marked by the main moraine.

In general, the surface of the Corral Creek moraine is subdued and has an aspect similar to that of the Home moraine, except for the presence of a greater number of large scattered boulders. A care-

ful search revealed a few stones that are slightly wind-cut, but none show faceting. Little wind-blown sand is present. The feeble wind action thus indicated, implies a less active and less prolonged period of wind activity than occurred during the Home substage.

The ice mass moving down Joe Wright Creek (Home Quadrangle) was larger than those in the other valleys, for it was fed from a larger area of accumulation below the high summits of the Medicine Bow Mountains to the west. This glacier moved into the Laramie River valley, where it built a moraine; it also pushed a lateral tongue down the valley containing the present Chambers Lake. This tongue reached into the drainage of the Cache la Poudre River, where a morainic complex was built that now dams the valley and holds in the waters of Chambers Lake. Recently an artificial dam has been constructed on one of these retreatal moraines to raise the level of the water of the natural lake. Light blue-gray bouldery till, with unweathered blocks of all the local rock types, is revealed in a road-cut through this moraine. This till is so fresh as to be in marked contrast to the highly weathered till of the Prairie Divide stage. It is also slightly fresher than the till of the Home moraine.

The difference in the amount of weathering of the till, the distinct topographic position of the moraines in the valleys; and the widespread distribution of comparable moraines lead to the conclusion that these features indicate a glacial substage separate and distinct from the Home substage. According to the terminology used, this is considered to be Wisconsin III.

LONG DRAW SUBSTAGE OF GLACIATION

Immediately below the cirques at the heads of Corral Creek and Long Draw Creek there are evidences of an ice advance. Below the cirque of Corral Creek there is an outwash plain, pitted with kettle holes (pl. 6, fig. 1)—material evidence for a slight readvance of glacial ice, although in this valley no terminal moraine was developed (Louis L. Ray, 1938). Remarkably fresh, soled and striated boulders occur in this outwash.

Below the lip of the nearby cirque of Long Draw Creek (secs. 7 and 17, T. 6 N., R. 75 W.) there is a low and poorly developed moraine, apparently contemporaneous in age with the pitted outwash plain of Corral Creek. These features are the youngest and least altered glacial deposits in the drainage basin of the Cache la Poudre River.

The name "Long Draw" is here given this glacial substage. Examination of many cirques throughout the Colorado Front Range in-

dicates that this slight advance is general and not peculiar to the mountains of northern Colorado. It is thus a definite stage of re-advance of the ice or a prolonged halt in the final recession. In the nomenclature here adopted it is considered to be Wisconsin IV.

PROTALUS SUBSTAGE

In the Corral Creek cirque lies a great ridge of angular debris, which from a distance appears to be a glacial moraine (pl. 6, fig. 2). However, close inspection of the mass of poorly sorted and angular boulders gives no indication of till or outwash of glacial origin. This ridge is a protalus rampart (Bryan, 1934), built of blocks from the cirque head wall, loosened by intense frost action, or nivation, and accumulated by rolling down over the snowbanks that once occupied the cirque. Because at the present time snowbanks of such size no longer form in the Corral Creek drainage, this is an ancient feature. Similar snowbanks and small ice masses, over which rocks roll each spring, still exist in the nearby cirques of the higher parts of the Colorado Front Range, in Rocky Mountain National Park. During the last general period of refrigeration the snowbanks, or perhaps the last remnant of glacial ice, still lingered in this shady head-wall region of the Corral Creek cirque, its record surviving only as this rampart of rough blocks.

Protalus ramparts may be seen in numerous cirques of the Colorado Front Range. They thus indicate a period, or periods, of slightly colder climate preceding that of the present.

SUMMARY

In the Cache la Poudre drainage basin there is direct evidence for an early Pleistocene glacial stage, the Prairie Divide, which is probably correlative with the Cerro stage of the San Juan Mountains. In the inner canyon of the Cache la Poudre there are terminal moraines of three substages of the Wisconsin; Home, Corral Creek, and Long Draw. Less conclusive evidence indicates that there is also a pre-Home substage of the Wisconsin. A protalus rampart in the valley of Corral Creek records a recent period of refrigeration, too feeble to produce ice tongues which moved from the cirques.

Similar features in other parts of the Southern Rocky Mountains are proof of a similar number of advances of the ice. On this account, the stages differentiated locally may be considered the records of climatic changes that were of wide extent and were not unique to the Cache la Poudre Canyon.

TERRACES OF THE CACHE LA POUDRE CANYON

THE CANYON

The Cache la Poudre River, with its headwaters at the Continental Divide, flows for about 58 miles through a deep, and in places narrow, mountain canyon. Near the village of Bellvue, the river leaves the canyon through a gateway in the hogback ridges and begins a meandering course across the Colorado Piedmont (fig. 1). The fall of the canyon floor between the headwaters and the mouth is more than 5,500 feet, so that the average gradient of the stream is approximately 95 feet per mile, or 1°. This is in marked contrast to the gradient of the stream between the mouth of the canyon and the confluence with the South Platte River, near Greeley, where the gradient is only about 10 feet per mile.

The inner canyon of the Cache la Poudre River, here discussed, is a deeply entrenched valley, cut below an older broad valley during the last great period of stream entrenchment, the canyon-cutting cycle. Numerous high bedrock spurs rising to more or less accordant heights indicate former positions of the valley floor, at each of which the stream excavated a valley broader than the present inner canyon. These stages are of the same age as the pediments of the lower country and therefore are not directly pertinent to the problem of the age of the terraces. The glaciers of the Wisconsin stage and the associated low gravel terraces are confined to the present inner canyon and are definitely younger than the rock spurs.

The inner canyon of the Cache la Poudre River is separable into two divisions, the glaciated portion above Home Post Office, and the unglaciated portion below. The gradient of the canyon floor in the unglaciated portion averages about 80 feet per mile, in the glaciated about 115 feet per mile. These, however, are by no means smooth gradients, for an examination of the river profile (fig. 9) shows a series of breaks in gradient. There are about seven such well-defined breaks in both the glaciated and the unglaciated stretches of this inner canyon. They occur mainly at constrictions, or "narrows," where the bedrock is resistant to weathering and the river has been able to cut only deep, narrow gorges. Where the bedrock is easily weathered, the valley has been widened, the walls are less steep and more widely separated, and the river gradient is smooth.

Large talus cones, developed along the valley walls of the inner canyon, indicate the great amount of weathering which has occurred since the canyon-cutting cycle of late Pleistocene time. The larger of the cones are below the lower limit of glaciation, at Home Post Office.

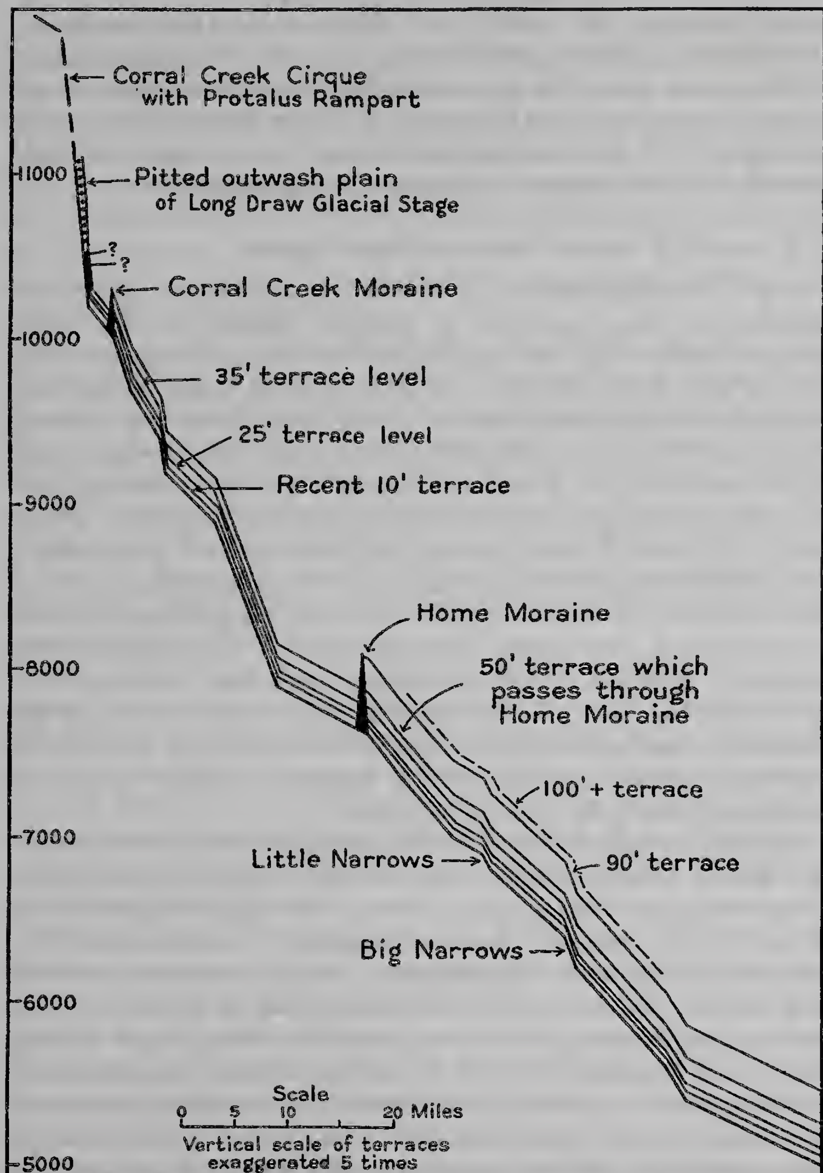


FIG. 9.—Generalized profile of the Cache la Poudre Canyon, showing terrace sequence and relation to glacial features.

Smaller, but well-developed cones occur in the glaciated portion of the canyon, indicating the rapidity with which some of the bedrock of pre-Cambrian granite and schist has disintegrated. The angular debris of these talus cones, in places roughly stratified by gravitational sorting, is displayed where the cones are dissected or cut by the river. A large part of the talus material consists of fine sand and comminuted rock, the products of local weathering and frost action.

NATURE OF VALLEY TRAINS

It is a recognized feature of mountain glaciation that glacier-fed streams carry large quantities of detritus. Because of their overloaded condition they build up their gradients and submerge the lower parts of the valleys with sand and gravel. These bodies of alluvium are termed the valley train, and by continued deposition they increase in height until the glacier has reached its point of maximum extension. On the retreat of the glacier the increased melt-water drainage removes much of the gravel and sand composing the valley train. Thus, in any one period of valley glaciation the lower portions of the valley, below the ice terminus, are first filled with fluvio-glacial debris and are thereafter, on the retreat of the glacier, more or less thoroughly cleared of this material. The pebbles and cobbles of the valley trains do not necessarily show the typical pentagonal, soled, and striated glacial form (Wentworth, 1936), but may be well rounded and give no evidence of their glacial origin (Louis L. Ray, 1935, p. 314). The remnants thus resemble any ordinary terrace recording a period of alluviation followed by a period of dissection.

Glaciers of three, possibly four, Wisconsin substages moved down the Cache la Poudre Canyon after the entrenchment of the stream during the canyon-cutting cycle. During each stage of glaciation a valley train was produced which was partially removed during the retreat of the ice from its position of maximum advance, marked by a terminal moraine. Each successive period of glaciation, each less extensive than the previous one, should be indicated by a terrace. The amount of glacial filling of the valley, and therefore the height of the valley train, is directly proportional to the size of the glaciation. Not only do greater glaciations endure longer, but the ice mass is larger and extends farther downstream. The terraces of the Cache la Poudre are not only comparable in number to the number of stages of valley glaciation, but certain terraces can be traced directly into terminal moraines. The details of the terraces and the methods by which they are correlated with each other and with the glacial stages are here set forth.

METHODS OF TERRACE STUDY

In the canyon of the Cache la Poudre River the terraces are common topographic features, in places rising steplike one above the other, or occurring as individual broad gravel flats, or as isolated gravel patches caught in minor inequalities of the rocky valley walls. Dissected remnants of these valley trains extend far beyond the canyon mouth and may be traced as terraces on the Cache la Poudre and South Platte Rivers. In order to carry the late glacial chronology of the mountains (see pp. 30-35) into the Colorado Piedmont, it is necessary to correlate the gravel terraces of the canyon with the terraces of the South Platte River.

A small portion of the valley train of the Home stage of glaciation is preserved as a terrace remnant, about 90 feet in height above the river, in front of and adjoining the Home moraine (figs. 8 and 10). Similarly, a remnant of the next lower valley train, whose height is about 50 feet above the stream, is preserved in front of the moraines of the Corral Creek stage, at Chambers Lake. Here, the river has exposed good sections through the moraines and the associated valley train. The transition may be followed between the heterogeneous materials of the morainal till to the roughly stratified fluvio-glacial materials of the valley train.

Downstream from the moraines, the terrace remnants have been mapped, and as shown in figures 9 and 10, they fall into a series of definite and correlatable groups. The highest of the terrace levels are the most poorly preserved, and stretches of several miles separate the remnants. The youngest terraces, on the other hand, are so numerous and have elevations above the level of the river which are so nearly the same that they may be separated into groups only with the greatest difficulty.

The elevations of terrace remnants above the river grade were carefully measured by hand level, from the water level at the time of measurement to the upper surface of the terrace. As the river grade is the only practical base from which to measure the height of the terraces, its fluctuation in water level from day to day, or hour to hour, is important. As the flow of the river, and thus its level, is regulated for irrigation, these fluctuations are highly irregular. A fluctuation of 2 feet, caused by the opening of water storage reservoirs near the headwaters of the river, does not materially effect the measurements of the higher terraces that lie from 35 to 90 feet above the grade of the river. However, the elevation of the low terraces, closely spaced and lying from 6 to 12 feet above the river, are seri-

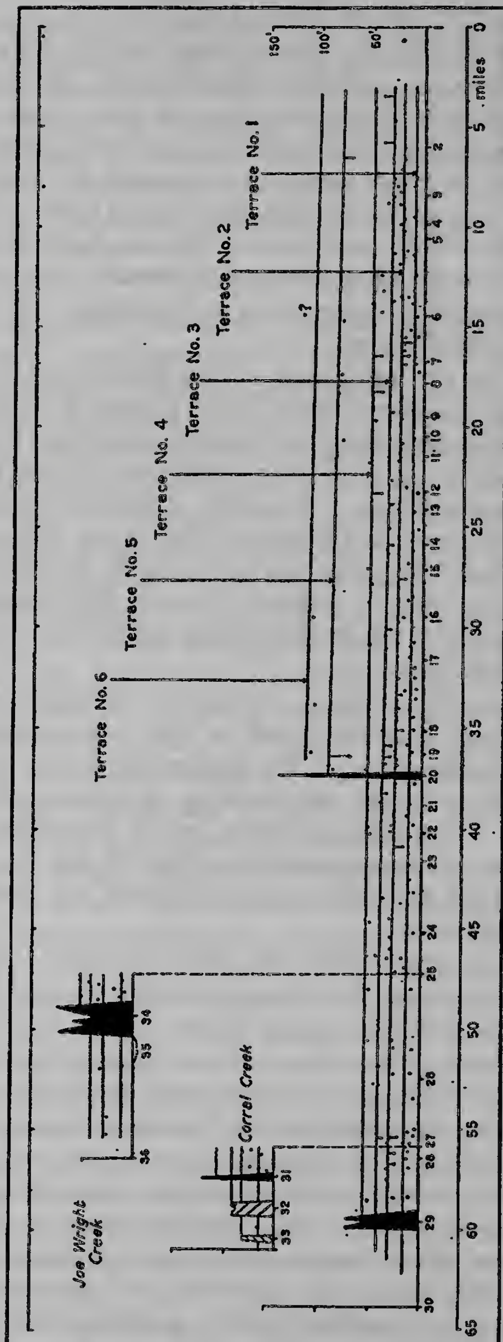


FIG. 10.—Diagram showing distribution of the terrace remnants and their height relative to the Cache la Poudre River within the canyon. Moraines shown in solid black; pitted outwash plain and protalus rampart of Corral Creek cirque are cross ruled.

ously affected. This inherent inaccuracy in the data makes a correct interpretation of the lower terraces difficult. Further inaccuracies arise because the original upper surface of many terrace remnants is not too well defined, and because many of the higher terrace remnants are covered with talus. Many terraces have been so eroded that their remnants show no trace of the original upper surface. Here, only the present upper limit of river-borne gravel can be measured and the original elevation of the terrace level must be estimated. In the correlation of terrace remnants it must be kept in mind that the remnants of a single terrace do not necessarily stand at the same elevation above the present stream. In any one portion of the canyon the present stream does not necessarily follow the course of the depositing stream and may intersect the originally graded plain of deposition at various angles, and thus the stream grade may be at unequal distances below the terrace grade. Furthermore, the heavily laden and swiftly flowing streams which deposited the valley trains probably did not produce plains of absolutely smooth slope. By reason of their great activity, they filled the valley to a general level, but there were doubtless many slight irregularities. Also, with the first and probably hesitating retreat of the glaciers, there were developed slight irregularities on the surface of the valley trains by the erosive action of the melt-water streams (Louis L. Ray, 1935, pp. 303-307).

All terrace remnants are slightly higher above the present stream grade at their points of origin, that is, at the terminal moraines of the glacial stages to which they are related, than at the mouth of the canyon. Profiles of the terraces show that there is a general tendency for the terrace remnants to converge toward the mouth of the canyon. This convergence is continued away from the mountain front, so that in eastern Colorado the higher terraces have been lowered, and several of the lower terraces have completely disappeared.

The lower terraces of the Cache la Poudre Canyon cannot be related to definite periods of ice advance from the cirques, but by analogy with the strictly glacial terraces are held to represent a local refrigeration. Each terrace is considered the representative of a period of increased cold and intensified frost action in the cirque areas of the higher mountains. The overloaded streams built up their grade and laid down a gravel plain similar to, but smaller than, the valley trains of the earlier glacial substages. With each change to a warmer and drier climate, these gravel flats were dissected.

The original correlation of the terraces of the Cache la Poudre Canyon was worked out on a large chart on which the river profile

was plotted with a horizontal scale of 2 inches to the mile, and the terrace remnants shown in pattern on a vertical scale of 2 inches to 100 feet. A similar chart on a much reduced scale, with the Cache la Poudre represented as horizontal (fig. 10), shows much of the data of the original profile.

There are in the canyon of the Cache la Poudre River six or more terraces, the oldest related to the oldest glaciation of the inner canyon, the youngest, which may represent several small terraces, so poorly defined that it is thought inadvisable to attempt a separation, but to classify these remnants as a single terrace of postglacial age. For descriptive purposes, the terraces are numbered from 6 to 1, from oldest and highest to youngest and lowest. They are discussed in this order.

TERRACE NO. 6

The highest and oldest terrace of the Cache la Poudre Canyon, No. 6, is poorly defined, and its presence is based on evidence which has resulted from the detailed study of the valley. The first line of evidence has been described on pages 31 to 33, where it has been pointed out that there is reason to believe there was a glacial advance in the inner canyon before the Home substage. This earliest glacier advanced only a few hundred feet farther down the canyon than the glacier of the Home substage, and almost all traces of it have been removed by subsequent erosion. However, this glacier must have built a valley train similar to, and slightly higher than, that of the later Home substage. During the long interstadial period between the recession of this ice and the advance of the ice of the Home substage, erosion removed almost all of the old valley train.

At three localities small gravel patches were found above the general level of the next lower, or No. 5, terrace. These form the second line of evidence for the No. 6 terrace. At Indian Meadows, near Dadd's Gulch, where the valley of the Cache la Poudre is unusually wide, a single gravel remnant lies on the south valley wall, 108 feet above the stream. Although this gravel may represent material brought down into the main valley by a tributary stream and deposited on the 90-foot terrace, No. 5, it may also represent either an unusually high remnant of the No. 5 terrace, or, what seems most reasonable, a remnant of a higher terrace, correlative with the pre-Home glaciation.

Another similar remnant of weathered gravel is perched on the north valley wall, about 4.5 miles upstream, at an elevation about 105 feet above the stream. At Hewlett Gulch another small body of

gravel is located on the valley wall some 120 feet above the stream. These gravel remnants lead to the belief that the No. 6 terrace once existed at a grade somewhat more than 100 feet above the present river, and that this terrace is correlative with the pre-Home substage of glaciation. In the lower canyon and in the Colorado Piedmont this terrace has either been removed or obscured and merged with the slightly lower No. 5 terrace.

The third line of evidence pointing to a No. 6 terrace rests on the low, gravel-capped, bedrock spurs, which represent the floor of the Cache la Poudre Canyon belonging to the pre-Home substage of glaciation. Below the moraine at Home there are numerous patches of gravel resting on low bedrock benches, which average about 20 to 30 feet above the present stream grade. These bedrock benches are the remnants of the surface on which the debris from the retreating glacier was deposited to form the No. 6 terrace. During the long interstadial period between the pre-Home and Home glaciations the gravel of the No. 6 terrace was largely removed and the bedrock valley floor dissected. During the later glaciations the old channel has been buried and reexcavated several times. In the canyon, above the Home moraine, no remnants of these bedrock spurs have been found, for they have been removed by the ice of the Home substage or transformed into roche moutonnée surfaces. The fact that the moraine at Home appears to rest upon the present bedrock floor of the canyon indicates that the spurs are not to be associated with the Home substage, but with the previous substage of glaciation.

TERRACE NO. 5

Approximately 90 feet above the Cache la Poudre River there is a gravel terrace, the remnants of which are found only in the valley below the moraine at Home. This terrace is held to be correlative with the advance of the ice of the Home substage and is the oldest and highest terrace in the canyon which may be directly correlated with a terminal moraine. Adjacent to the Home moraine there are several terrace remnants which lie at elevations of 85 to 90 feet above the level of the stream (fig. 8, see terrace marked "5"). A terrace of small extent, near the moraine, with an elevation of 70 feet is considered a reduced portion of the No. 5.

Ten miles downstream, at Stevens Gulch, another large remnant is preserved at 78± feet above the river. Here the general level of the terrace is somewhat lower than 90 feet. This height, however, may not be a great deviation from the actual level of the old surface of the terrace along the axis of the river at this point. Six miles farther

east, at Hewlett Gulch, an outcrop of gravel at 80 feet above the stream, indicates a continuation of this terrace.

At the mouth of the Cache la Poudre Canyon, near the Greeley Waterworks Dam, gravel occurs on the valley wall at an elevation of 72 feet above the stream. The upper surface of the deposit has been removed by erosion, but the height of the deposit is such that this is assuredly a remnant of either the No. 5 terrace or the possible older terrace, referred to previously as No. 6.

The gravel of the No. 5 terrace is not definitely distinguishable from that of the younger terraces. It is well rounded, decreasing in size from a maximum of 4 feet near the moraine to 10 to 12 inches at the mouth of the canyon. It is only slightly iron-stained, and not deeply weathered.

The small number of remnants may be considered a challenge to their correlation as a terrace. However, when one considers that no remnants have been found in the canyon above the Home moraine, whereas the remnants at the moraine are definite and obviously related to the moraine, there seems to be no good reason for doubting its validity as the representative of an ancient valley train, contemporaneous with the ice that formed the Home moraine. The upper surface of the No. 5 terrace is considered, therefore, to mark the maximum filling of the valley by debris at the time of the Wisconsin II glaciation.

TERRACE NO. 4

Below the No. 5 terrace a better-preserved series of terrace remnants lie at elevations of approximately 50 feet above the grade of the river. In the lower portion of the canyon, from the mouth to the North Fork, terrace remnants at elevations accordant with this height are lacking. However, near the mouth of the canyon, on the plains near Bellvue, there are terraces with elevations of 40 feet and more, which are considered the equivalent of the 50-foot terrace of the canyon. Above the North Fork the terrace remnants are more closely spaced and better preserved, with especially good examples at Eggers, Elkhorn Creek, Stove Prairie Landing, and Roaring Creek (fig. 10). At Home, below the moraine, there is a remnant of this terrace at approximately 54 feet above the river. Upstream from the Home moraine are a series of remnants lying at the 50-foot level (figs. 8 and 10). Two and a half miles above the Home moraine, at Roaring Creek, there are well-preserved flats at 50 and 52 feet above the river. The gravel of these remnants is comparatively fresh and unaltered.

In the Middle Fork of the Cache la Poudre River, below Chambers Lake, the No. 4 terrace can be carried directly to the moraines of the Corral Creek stage of glaciation, by a series of accordant terrace remnants, which impinge on the moraines. Here a gradual transition can be traced from the till of the moraines to the stratified and sorted material of the terrace. At this point (fig. 10) there is definite evidence that the No. 4 terrace is the product of the Corral Creek glacial substage, just as the No. 5 is held to be the product of the Home glacial substage.

Following the main Cache la Poudre River toward its headwaters at Milner Pass, the No. 4 terrace may be traced to the moraines of the Corral Creek stage at Chapin Creek. They may also be followed up the tributary Corral Creek to the moraine which marks the type locality of the Corral Creek glacial substage. No traces of gravel have been found above these moraines which can be interpreted as belonging to this terrace. The direct merging of the terrace gravel with the moraines, together with the lack of remnants above the moraines, and the relatively large number and close spacing of remnants at approximately 50 feet above the river throughout the Cache la Poudre Canyon, make this terrace the most valid and give certainty to its date as the valley train of the Wisconsin III glacial substage.

TERRACE NO. 3

In the upper canyon of the Cache la Poudre River, remnants of the No. 3 terrace [6] occur at an elevation about 40 feet above river grade and in the lower canyon at 30 feet. The decrease in height is marked, but the remnants are more numerous and more closely spaced than the remnants of the higher and older terraces. At Home, where the terrace passes through the moraine, remnants are broad and easily recognizable (fig. 8).

Especially well preserved are those terrace remnants which lie below the moraines of the Corral Creek substage of glaciation. Above these moraines are numerous low and modified remnants of glacial debris, probably retreatal phases in the recession of the ice from the Corral Creek moraines, perhaps remnants of this terrace. Adequate information is lacking which would definitely prove a direct relationship between the No. 3 terrace and the Long Draw moraines, for in no place can the terrace gravel be found in contact with the moraine, as in the case of terraces Nos. 4 and 5. However, one may assume

[6] Referred to in preliminary report as 25-foot terrace and incorrectly correlated with 30-foot, or Kersey terrace (Bryan, 1937).

that a genetic relationship with the Long Draw moraines is not only reasonable, but most probable.

TERRACE NO. 2

The second terrace occurs about 18 to 25 feet above the grade of the river. It is represented by more remnants of greater lineal extent than any of the older terraces. Between the mouth of the canyon and the mouth of the North Fork, a long series of terrace remnants lie between 18 and 22 feet above the river. Below the Home moraine is another long expanse of this terrace at 24 feet. Below the Corral Creek moraine is a large and well-preserved terrace remnant with a surface several acres in extent, at an elevation approximately 25 feet above the stream. Similar remnants below the mouth of Long Draw Creek also have a height approximately 25 feet above the stream. There can be no mistaking the identification of this terrace from place to place, and its validity as a stage in the history of the valley cannot be doubted.

No correlation is observed between this terrace and any glacial stage in the Cache la Poudre Canyon. It is, however, tentatively thought to be correlative with a climatic change, probably the one which produced the protalus rampart of the Corral Creek cirque. Such a correlation seems justified on the basis of the terrace and the glacial sequence, but it must await further proof.

TERRACE NO. 1

Throughout the length of the Cache la Poudre Canyon and its major tributaries there are low gravel terraces, ranging from 6 to 12 feet above the level of the stream. It is possible that these may represent two or more distinct terrace levels, but no attempt has been made at subdivision, and they have been grouped into a single terrace, the average height of which appears to be about 8 feet above the stream. Because of the constant fluctuation of the river and the small height of these terrace remnants, the percentage error in the determination of their height is relatively great, as has been previously noted. A bouldery terrace, the general height of which is not more than 6 feet above the stream, may be the result of unusual floods of the river in the present cycle. Terrace remnants at heights near 12 feet probably represent an older terrace, not now subject to the stream floods. The term "No. 1 terrace" is thus a blanket name for low terraces of relatively recent origin. On the plains, immediately east

of the mountain front, these low terraces are indistinguishable and have apparently merged with the flood plain of the river.

CORRELATION OF THE TERRACES OF THE CACHE LA POUDRE CANYON WITH THOSE OF THE COLORADO PIEDMONT

It has been shown that the terrace remnants of the Cache la Poudre Canyon fall into six grade lines, the elevations of which above river grade near their points of origin are: 100+, 90, 50, 35, 25, and 6-12 feet. There is doubt as to the validity of the 100(+)-foot terrace, and the lowest terrace level is probably a complex of recent terraces.

Except for the 90-foot terrace gravel, which is slightly iron-stained, no substantial difference can be detected in the amount of weathering of the gravel of the lower terraces, for all the terraces are sufficiently young so that the lapse of time has been too small to produce significant weathering.

The terraces of the Cache la Poudre Canyon are separated from the older broad valley levels of the Cache la Poudre River by a period of canyon-cutting. It has been shown that the alluvial terraces of the Cache la Poudre and South Platte Rivers in the Colorado Piedmont are also separated from the older and higher gravel-capped pediments by a period of stream incision. This period of incision by the streams was simultaneous in the mountains and the plains. Terraces of the inner canyon are found to be correlative with the alluvial terraces of the Cache la Poudre and South Platte Valleys.

Near the mountain front no terrace remnants have been found which can be definitely correlated with the No. 5 and older (?) terrace of the mountain canyon. However, a definite correlation is possible between the 50-foot terrace of the canyon, the No. 4, and a terrace level of about 40 feet elevation above the Cache la Poudre River on its south bank near the village of Bellvue. This terrace may be followed more or less continuously from the vicinity of Bellvue, down the Cache la Poudre River to the South Platte River, where it is seen to be correlative with the Kersey terrace (pp. 25, 26). The lower Kuner terrace is held to be the correlative of the 35-foot terrace of the mountain canyon.

If the No. 4 terrace of the mountain canyon is the correlative of the Kersey terrace, it seems only reasonable to believe that the No. 5 terrace, of Home age, is correlative with the Pleasant Valley terrace. If the No. 6 terrace actually exists, it is doubtful if remnants of it could be distinguished from the Pleasant Valley terrace away from the mountain front. Thus, it would seem that the following

correlation may be made between the glacial substages of the mountain canyon, the terraces of the canyon, and the terraces of the Colorado Piedmont:

Glacial substage	Canyon terraces	Colorado Piedmont terraces
Pre-Home substage (Wisconsin I ?)	No. 6, or 100(+)-foot terrace	?
Home substage (Wisconsin II)	No. 5, or 90-foot terrace	Pleasant Valley
Corral Creek substage (Wisconsin III)	No. 4, or 50-foot terrace	Kersey
Long Draw substage (Wisconsin IV)	No. 3, or 35-foot terrace	Kuner
Protalus rampart (Wisconsin V)	No. 2, or 25-foot terrace	River flood plain
Post-glacial or Recent	No. 1, or 6- to 12-foot terrace	

FOLSOM SITES IN THE REGION AND THEIR BEARING ON THE GEOLOGIC AGE OF THE CULTURE

Two other sites in the Colorado Piedmont shed light on the antiquity of the Lindenmeier site. One of these has been described by Figgins (1933), the other has been mentioned before only briefly (Bryan, 1937).

Near Dent, a siding on the Union Pacific Railroad, sec. 13, T. 4 N., R. 67 W. (Greeley Quadrangle), large bones were discovered and reported to Father Conrad Bilgery, S. J., who, on excavation, found an artifact associated with the bones. Father Bilgery enlisted the aid of J. D. Figgins, at that time associated with the Denver Museum, who continued excavations at this site, uncovering a large number of mammoth skeletons, mostly those of young females, and another artifact, associated with the bones. These artifacts are spear points of the type usually referred to as "Folsomoid" and are similar to points which have been found recently at the Lindenmeier site. Thus, the Lindenmeier and Dent sites appear to have been contemporary.

The bones and artifacts at Dent occur on the inner edge of a gravel terrace adjacent to the valley wall and near the top of the gravel. In this vicinity, the top of the terrace lies approximately 27 feet above the flood plain of the South Platte River. The site is accordant in height and has gravel similar to other terraces in this

part of the South Platte Valley which are considered remnants of the Kersey terrace.

Near the village of Kersey Mr. Forrest Powars and his son Wayne discovered Folsom points of the normal type, together with numerous snub-nosed scrapers, in a sandy field. The sand is windblown and rises as a dune in a gentle slope from the level of the Kersey terrace to a height of approximately 30 feet (pl. 3, fig. 1). The artifacts are found in the upper few feet of the sand over a large area, but there is no definite culture layer. However, as the artifacts are similar to those found at the Lindenmeier site, it appears that they are contemporaneous and that the Folsom hunters camped on a sand dune blown from the flood plain of the river when the river flowed at the level of the Kersey terrace.

The Dent and Kersey sites confirm the correlation between the culture layer of the little valley at Lindenmeier, and the Kersey terrace, and show that the Lindenmeier site was not the only camping place of the Folsom hunters in the Colorado Piedmont. All three localities were occupied after the upper surface of the terrace had been built and before its dissection. In other words, the sites were occupied either during the maximum advance of the Corral Creek glaciers, or soon after the beginning of their retreat. The finds at Dent are in the upper part of the terrace, just how near the top is not quite clear from Figgins' (1933) account. At Kersey the artifacts do not occur on the terrace but slightly above the level of the terrace in dune sand. Probably the river periodically washed the foot of the slope and periodically shifted, leaving a barren channel. From this channel the sand was blown onto the terrace. Since the artifacts are not buried more than 2 to 3 feet, we are led to believe that the camp must have been occupied at the end of the period of building of the sand dunes or at the time when the glaciers of the Corral Creek substage had already reached their maximum.

GLACIATION AS A CHRONOLOGY

The culture layer at the Lindenmeier site is of the same age as the Kersey terrace and cannot have continued to form for any great length of time after dissection of the terrace began. The Kersey terrace is the equivalent of the No. 4 terrace in the Cache la Poudre Canyon, which in turn is the outwash train of the Corral Creek glaciers. The Lindenmeier culture layer is thus of the same age as a glacial substage which is presumably Wisconsin III. In order to complete the history of the Lindenmeier site and to provide as close an approximation to a date as is possible in the present state

of knowledge, it is necessary to relate the glacial substages in the Cache la Poudre Canyon with the North American and European glacial chronologies. Such a correlation involves grave possibilities of error in itself, and further, the standard chronologies are not without flaw. These difficulties are here set forth in considerable detail.

The discovery on all the continents and many oceanic islands of deposits laid down by glaciers that have since disappeared, long ago raised the problem of the contemporaneity of these ancient glaciers. With the further discovery that glaciation is multiple, that at nearly every place two or more, usually four, major glacial advances have occurred, and that these advances of the ice were separated from one another by intervening times of warm climate comparable to, or warmer than, the present, the problem was intensified.

All phases of this problem have been recently summarized by Daly (1934, pp. 30-41). He has ably marshaled all the evidence on several lines of analysis, which indicates contemporaneity. The viewpoint is not universally accepted (Lugn, 1935, p. 31) and is not at present subject to absolute proof. Nevertheless, the authors hold with Daly that the major advances of the great continental ice sheets were broadly contemporaneous. It does not necessarily follow that the climaxes of these ice advances were precisely synchronous. In fact, American geologists have brought forward proof of a progressive shift from east to west of the main ice center throughout the last, or Wisconsin, glacial stage. Yet, as methods of obtaining data are imperfect and subject to error, there is an unavoidable tendency to use any ascertained date as a world-wide reference point.

In the following discussion, the European chronology will be first considered, and thereafter the North American. The two will then, so far as possible, be brought together and a correlation made with the glacial stages of the Cache la Poudre Canyon.

THE EUROPEAN GLACIAL CHRONOLOGY

THE MAJOR ICE ADVANCES

Investigation of the European glacial deposits and related interglacial sedimentary beds has been very active in the past 20 years. At present so many new facts and conclusions are being published that no general statement on chronology can be made that will meet the views of all authorities.

The concept that the glacial period was marked by four great glacial advances, separated by periods of mild climates as warm as, or warmer than, the present, is generally accepted. This is the

familiar subdivision current for many years, which is set forth in table 1. There is, however, a growing tendency to consider that each of the glacial stages was multiple and consisted of at least two ice advances, separated by a definite interstadial period of ameliorated climate. This viewpoint is supported by many new field facts relating to the terrace systems, loesses, and pollen-bearing beds of the periglacial region of South Germany. The recognition of weathering zones as evidences of the milder climates of interglacial, or interstadial periods, has been of great importance. Also, the study of pollen and other vegetative remains has led to the recognition of many beds deposited in climates as warm as, or warmer than, the present and therefore of interglacial or interstadial age. This recognition of

TABLE I.—*General Glacial Chronologies*

Climatic expression	Alpine area	North German Plain	Continental glaciers of the United States
4th glacial	Würm	Weichsel (incl. Warthe)	Wisconsin (incl. Iowan)
3rd interglacial		"Saw"	Sangamon
3rd glacial	Riss	Saale	Illinoisan
2nd interglacial		"Es"	Yarmouth
2nd glacial	Mindel	Elster	Kansan
1st interglacial		?	Aftonian
1st glacial	Günz	?	Nebraskan (Jerseyan)

a general climatic rhythm has forced the conclusion that many of the glacial stages heretofore recognized are complex rather than simple.

This viewpoint is also influenced by the calculations of Milankovitch (1930), whose astronomical theory calls for double or triple cold stages at each glaciation. Direct correlation of glacial substages with the cold periods indicated by the astronomical theory is advocated most strongly by Soergel (1925), and this system has been admirably set forth, with disarming ingenuity and candor, by Zeuner (1935).

It is obvious that the older subdivisions are of less importance in this study. Our concern lies with the subdivisions of the last glacial stage and of the long interval of transition to the present. In this field there is at present no agreement among European students, except that the efforts of each of them makes more apparent than

before the complexities of the advance and the final retreat of the last ice. If we accept, for example, the views of Gams (1938), it is necessary to recognize 10 periods of ice advance during the last, or Wisconsin, glaciation. Each ice advance is separated from the other by a time of slightly ameliorated climate, and many of these intervals are recognized by deposits containing pollen, diatoms, and other plant remains, or by fossil animals, either vertebrate or invertebrate.

There are many obvious difficulties in the geologic proof that a certain fossiliferous bed is older than the deposits of one ice advance and younger than the deposits of another. Yet each of these numerous, widely scattered deposits records an ameliorated climate, a definite retreatal or interstadial, or interglacial time. Each is an entity whose presence must be considered. Each represents a period of more genial climate which must be fitted into the pattern of successive climatic fluctuations. The continued study of these deposits and the discovery of new deposits forces reinterpretations of the strictly glacial deposits of the times of ice advance. Whether or not the 10 periods advocated by Gams survive the test of continued study of the problem, it seems evident that the events of the last ice age have been oversimplified. The effect of these newer viewpoints on the interpretation of work in geochronology will be further emphasized.

LATE-GLACIAL CHRONOLOGY

To the classic researches of Gerard De Geer we owe the invention of the method of geochronology by the counting of varves. These double layers of silt and clay silt are the unique deposits of glacier-fed lakes. The silt is deposited by the agitated waters of summer, the clay by the still waters of the ice-locked winter season. The measurement and correlation of such layers required much labor, skill, and judgment, and the scientific world has accorded generous credit to De Geer and his Swedish coworkers for their great accomplishment. The same tribute must be paid to Sauramo and other Finnish geologists for their extension of the chronology to the east side of the Baltic Sea, and also to Antevs, who has found in North America varve sequences exceeding those of Europe in the total number of years by more than three times.

The method, however, is limited by the existence of suitable clays. Not every retreating ice front acted as a dam to hold in a proglacial lake in whose bed varves were deposited. The same ice front that at times during the retreat laid down varves, at other times lay on

the land, or was flanked by salt water, so that no varves were formed. Thus, however perfect the chronology attained by varve counts, it is applicable to a part of late glacial time only. The gaps in the chronology must be filled by estimations of one type or another. If this discussion appears to emphasize these gaps, the reason lies in the present-day tendency to a glib assumption that the dates of many Pleistocene events have been fixed. They have been merely estimated. Skill, judgment, and the result of much labor by many earnest geologists have all contributed to these estimates. Nevertheless, as shown herein, the results have no binding authority and are at best provisional.

As shown in figure 11, which is based on the map by Antevs (1928), the last ice in North Europe deposited three morainal systems, the Fläming, the Brandenburg, and the Pomeranian (Great Baltic). Each moraine represents an advance of the Scandinavian ice sheet after a period of retreat. Opinions differ as to the length of these periods of ameliorated climate and their value in classification, but all students admit that in each interval the ice retreated and the climatic conditions may have been somewhat similar to those of the present.

The question of the age of the Fläming moraine, which is also termed the Warthe glacial stage, is still the subject of much discussion (see the brief review by Gams, 1938). Some hold that this stage is the Third Glacial, or the equivalent of the Riss stage; others, an advance just before the last ice age; still others consider it the first forward shove of the last ice. Thus, the Warthe occupies in Germany much the place of the Iowan of North America. If, following the recent decision on the Iowan (Kay, 1931, and Leighton, 1931), the Warthe is considered as an early substage of the last ice age, it may be the first major advance. It would then fit into the scheme of Soergel (1937) and Zeuner (1935). This placing of the Iowan as the first Wisconsin advance in North America is not, however, universally accepted by American geologists (Leverett, 1939, and Lugn, 1935).

The Brandenburg moraine, or Weichsel substage, is generally believed to represent the climax of the last ice age, except by De Geer, who has always believed that the Pomeranian should hold that honor. Most students now consider that the last glaciation had three maxima, the Warthe, Weichsel, and Pomeranian substages, the designations of which they frequently abbreviate to W1, W2, and W3.

The recessional stages during the retreat from the Pomeranian moraine are shown in figure 11, after Antevs (1928), whose names

FIG. 11.—Map showing moraines of the last glaciation and retreatal substages on Europe. Modified from Antevs.

for the intervals of retreat are followed. The advances and retreats involved in these time intervals, as interpreted from Antevs' text (1928), are shown diagrammatically in figure 12.

No diagram is attempted for the retreat from the Fläming moraine, although it may have been, and according to Soergel (1937) was, quite complete between the Fläming (Warthe) advance and the Brandenburg (Weichsel) advance. Similarly, the retreat from the Brandenburg (Weichsel) and readvance to the Frankfurt-Poznán moraine is shown by but two simple lines. It is probable that this is an oversimplification and our ignorance of the facts prevents

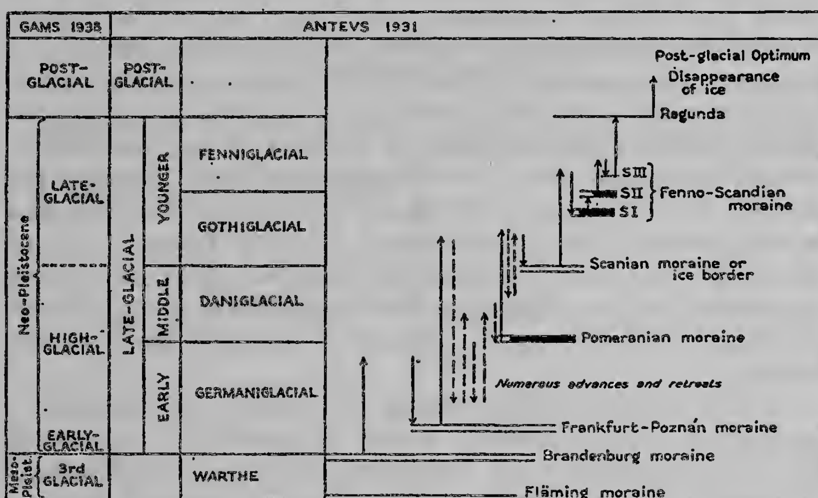


FIG. 12.—Subdivisions of the late glacial period, with diagrammatic representation of the several advances and retreats of the ice. Moraines shown in black are included in the next youngest substage.

representation of the complications that probably exist. From the Frankfurt-Poznán moraine to the Pomeranian moraine, there were numerous advances and retreats. These movements were complicated, and the data are obscure, but the problems involved are being vigorously attacked by Richter (1937) and others.

The time of final dissipation of the ice began with the retreat from the Pomeranian moraine. To some geologists this marks the end of the glacial period, a viewpoint set forth by Gams (1938), whose classification is shown on the left in figure 12. From the standpoint of geochronology, this interval of time is the most important, as parts of it have been measured by the methods of varve-counting.

Figures 11 and 12 show that this interval is divided into the Daniglacial, Gothiglacial, Fenniglacial, and Post-glacial substages, which are separated from each other by halts in the ice retreat or by other ascertainable events. The relation of the intervals to the moraines varies. Thus, the time necessary to form the Pomeranian moraine is held to be part of the Germaniglacial, and the time interval of the Scanian halt is assigned to the Gothiglacial. The first two halts of the Fennoscandian (Salpausselkä) moraine are also part of the Gothiglacial. The third halt falls in the Fenniglacial. This third period of recession is terminated by the bipartition of the ice mass at Ragunda.

The length of these time intervals is only partly known. The Post-glacial time interval is estimated to be 8,700 years on the basis of varve counts and estimations by Lidén (1913), which are only in part published. The extensive work of De Geer (1926 and earlier papers) on varves yields a complete sequence of 1,703 years for the Fenniglacial, which is partly confirmed by the work of Sauramo (1928). For the Gothiglacial there is no complete varve count. Sauramo has shown that the Salpausselkä double moraine required 670 years, and he has counted 1,250 or more annual varves in Finland, south of this moraine. De Geer (1926) has long sequences of varves in south Sweden, but the time interval of the Gothiglacial is nevertheless an estimate. Some authors give 2,500 and some 3,000 years for this interval.

De Geer (1926) identifies one of the moraines of southwestern Sweden, apparently somewhat beyond the position of the Scanian halt, as the equivalent of the Pomeranian. He gives, without full explanation, a date of 18,000 years ago for this supposed Scanian-Pomeranian moraine. This figure has been accepted without much question by many coworkers. Antevs (1928, pp. 157-160) discusses the problems involved at considerable length, and following several Danish geologists and his own field work, considers that the Pomeranian is represented by the East Jylland moraine of Denmark. Thus, he makes clear the existence of the time interval that he calls the Daniglacial. He estimates this time interval to be 10,000 to 15,000 years long, but there is no continuous varve count to support this estimate. The moraines in southern Scania, which De Geer (1926, pl. 3) correlated with the Great Baltic, or Pomeranian, are, as Antevs points out, much younger. De Geer (1926) gives an estimate of 9,500 years as the time interval between these moraines and the Ragunda bipartition of the Fennoscandian ice mass.

The length of the Gothiglacial, that is the interval from the halt in Scania (southern Sweden) to the end of the halt at the Fenno-

scandian moraine, is not distinctly set forth by De Geer, but Antevs (1928, p. 160) estimates it to be 2,000 years, plus the 670 years required for the building of the moraine which was determined by Sauramo in Finland. Sauramo (1928) states that he counted 2,400 varves in southern Finland, which together with the time interval of 670 years for the moraine would give 3,000+ years for the length of the Gothiglacial—a figure which is accepted by many authors.

The length of the Fenniglacial interval is given by De Geer (1926) as 1,703 years. This interval includes the period of retreat of the ice from the moraine to its bipartition at Ragunda. Sauramo (1928) has found this interval to be almost the same length as that given by

TABLE 2.—*Correlation of Swedish and Finnish Geochronologies, According to Sauramo*

Years of Swedish chronology	Years of Finnish chronology	Intervals between correlated positions in ice retreat in Sweden	Intervals between correlated positions in ice retreat in Finland
(at Ragunda) 0	Not determined		
— 500	1,100		
		600	580
—1,100	520		
		400	420
—1,500	100		
		100	100
—1,600	0		
		400	500
—2,000	— 500		
		1,000	900
—3,000	—1,400		
	Totals	2,500	2,500

De Geer. The relations, shown in his figures 18 and 19, reconcile the two chronologies. The data of these figures are here reproduced in table 2. It will be noted that there are discrepancies, but that for the whole period counted, they balance out. However, for the Fenniglacial, De Geer gives 1,703 years, and Sauramo 1,100 years of his chronology, plus 500 years of the Swedish, or only 1,600 years.

The complex glacial chronologies of Europe have been reviewed and an attempt made to clarify the European picture of the recession of the ice of the last glaciation. It has been shown also that the length of the Late-glacial period of Europe is largely estimated and that the varve counts give sure information for only a small part of the total time involved.

GEOCHRONOLOGY IN NORTH AMERICA

METHODS AND RESULTS

Estimates of the time back to the last ice age were made long ago, using many geologic methods, of which the most important was the rate of recession of Niagara Falls (for history, see Taylor, 1913). This method is supplemented by Antevs (1922, 1928, and 1931), who has combined with it the system of geochronology introduced by De Geer. There are, however, many difficulties in providing a complete chronology, primarily because varved clays are lacking in suitable positions, and secondarily because the details of geologic history are not wholly known, as much of the work in glacial geology has been in the nature of reconnaissance. Compared to the intensive study of the Pleistocene in the Baltic region, work in North America has lagged in the past 30 years. The material which follows is largely a critical review of the long-continued work of Antevs, who has summed up the difficulties in the introductory paragraphs of his paper of 1936.

As shown in figure 13, Antevs measured 5,500 varves from New Haven to Hartford, 4,100 from Hartford to St. Johnsbury, and 2,000 from Montreal River to a point north of Cochrane, Ontario. These intervals in the retreat are the only ones for which there is a geochronological dating, and the other intervals must be estimated in one way or another.

The interval from Stony Lake to Mattawa is estimated on the rate of retreat of Niagara Falls. Obviously this estimate is based on the present rate of retreat which has been established by historical means and by certain assumptions as to variations of the rate of recession in the past by reason of variations in the quantity of water pouring over the falls. However much care may have been put in such an estimate, it has sources of error quite different in amount and in kind from the errors of varve measurement.

In table 3, the several retreatal substages, their distances from each other, and various measurements and estimates of the time intervals are shown. In columns 2 and 5 are shown Antevs' estimates of 1928 and 1931, the differences in which will be discussed. Considering column 2 first, the elapsed time from the present to the moraine at St. Johnsbury, Vt., is $15{,}000+x+y+z$, in which x and y are unmeasured intervals of the retreat, and z is the time required for the melting of the ice from a point near Cochrane to the present. The period of ice retreat from Montreal River to a point beyond Cochrane is 2,000 years, represented by varves counted by Antevs. The period of retreat from Stony Lake to Mattawa is based on the

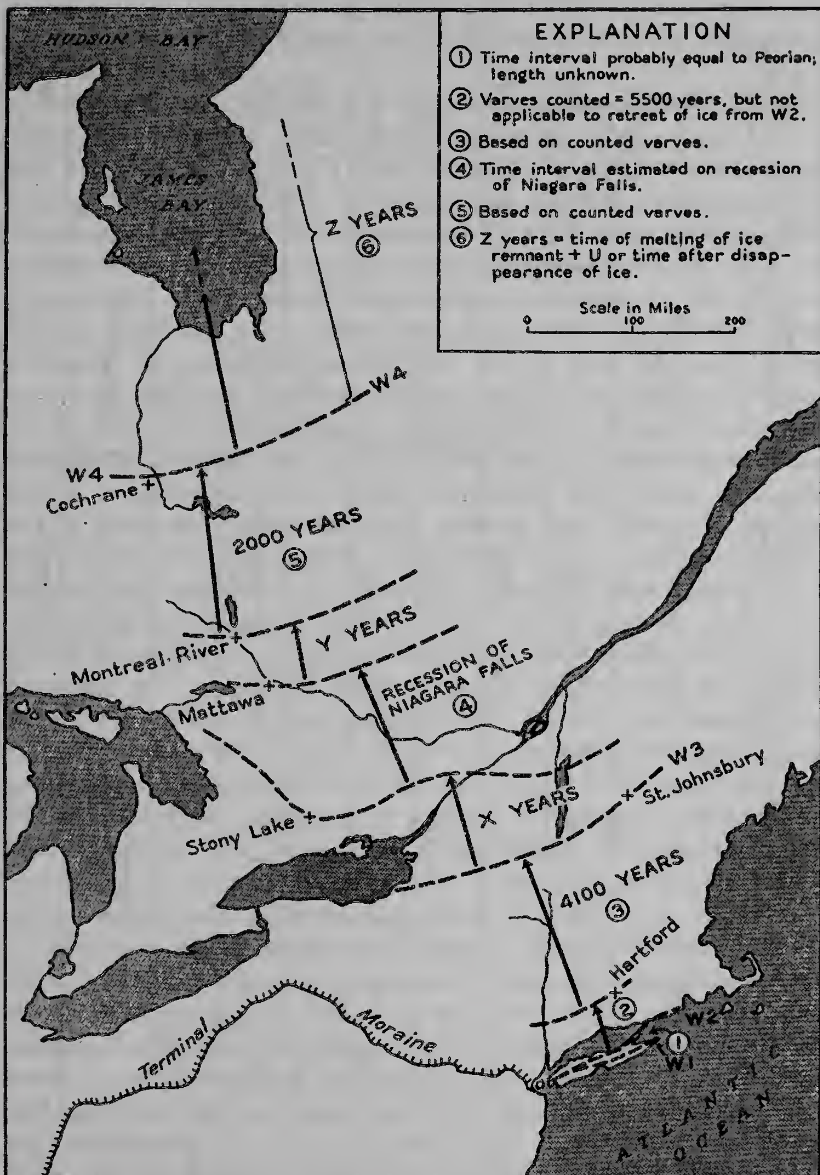


FIG. 13.—Map showing retreat of the continental glacier in eastern North America. Modified from Antevs.

TABLE 3.—*Recession of the Last Ice According to Various Estimates*

	1	2	3	4	5	6	7
	Distance (km.)	Time (years) Antevs, 1928	Rate of recession (yrs./km.)	First recalculation (Bryan)	Time (years) Antevs, 1931	Rate of recession (yrs./km.)	Second recalculation (Bryan)
Present time to time of disappearance of ice in James Bay plus retreat from Cochrane	1,500–1,800	*z*	(0.7)	1,000+*u*	2,000+ and *u*=7,000	(1.25)	1,875+*u*
Cochrane from Montreal River	1,200	2,000	1.4	2,000	} 6,000	1.25	{ 200? 725 1,500
Montreal River from Mattawa	850	*y*	(1.4)	1,200		1.10	1,000
Mattawa from Stony Lake	750	13,000	17.3	13,000	} 10,000±		
Stony Lake from St. Johnsbury	525	*x*	(17.3)	9,000			10,000
St. Johnsbury from Hartford	298	4,100	13.0	4,100	4,100	13.00	4,100
Hartford from Harbor Hill	95	5,500	(13.0)	1,235+800= 2,035	5,500 } 11,500	(13.00)	2,000
Harbor Hill from Ronkonkoma	0-20	2,000			2,000		
Elapsed time to St. Johnsbury = Pomeranian		15,000+*x*+*y*= 16,400–17,400 +*z*		26,200+*u*	25,000±		15,300+ *u*=22,300
to Harbor Hill = Brandenburg				32,300+*u*			21,400+ *u*=28,400
to Ronkonkoma = Iowan = Warthe		28,000+*z*= 37,000		?	36,500		?

recession of Niagara Falls. The missing intervals x and y are estimated at 1,400 to 2,400 years, but no information is given as to how the estimate is made, except general statements that ice retreat was rapid in these areas.

The interval St. Johnsbury to Hartford was determined by Antevs (1922) by numerous measurements of varves in the gray clays of this area. Here there is a long sequence of 4,100 varves, representing the same number of years. The interval of retreat from Hartford to New Haven is represented by 5,500 varves, measured by Antevs in the red clays of this area, largely before 1922. This sequence has been correlated with a similar sequence in the Hudson Valley. However, it has never been demonstrated that these varves represent the retreat of the last ice. In the New Haven area the top of the clay beds is always eroded and the base largely unknown. At Berlin, Conn., according to observations by Bryan, the clay is overlain by a solifluction layer, or warp, and the upper part of the clay is so weathered as to destroy its original lamination. It is also cut by joints and cracks containing colloidal clay. This zone has the character of the lower part of the B-horizon of a weathering profile. It thus appears that the clay has been exposed and has suffered from weathering in a climate at least as genial as the present. At a later period the upper part of the soil zone was carried away and a warp developed in a climate of Arctic severity. Leached clay is reported by Antevs at station 129 (Middletown, Conn.) and station 134 (Berlin, Conn.), and various kinds of disturbed or changed clay at nearly every locality from New Haven to Berlin (Antevs, 1928, pp. 184-188). On this evidence, it appears that the red clays of the Berlin area are older than the last interglacial, or interstadial, and may belong to an earlier ice advance. Under such an interpretation, varve measurements of these clays cannot be used in this sequence.

There is a further difficulty to be faced. Antevs follows all earlier authorities in assuming that the two moraines on Long Island were the result of a single period of ice advance. If this were true, they represent a forward movement to the southerly moraine, or Ronkonkoma, a slight retreat and a forward movement to the Harbor Hill moraine. Such a history might require only a short time. For the time interval, Antevs allows 2,000 years. Recent work in southern New England (Bryan, 1936) indicates that the Watch Hill moraine of Rhode Island, which is the equivalent of the Harbor Hill moraine of Long Island, differs markedly from the moraine of Cape Cod and Marthas Vineyard in its preservation of glacial topography and in its state of weathering. The moraines of Cape Cod and Marthas

Vineyard lack true morainic topography and are formed of sand and till stained by limonite. The relatively fresh aspect of the topography and the till of the Watch Hill moraine are proof of its relative youth and indicate that it is separated from the earlier moraines by a long interval of time. Between the fresh Harbor Hill moraine and the older Ronkonkoma this difference is implied in the descriptions by Fuller (1914). His statements make it impossible to believe that these two moraines record merely a pulsation at the maximum advance of the ice. They must be separated from each other by an interstadial, if not an interglacial period of weathering. Insofar as this point of view has merit, it is a mistake to attempt to carry a reckoning of the chronology, based on varve counts, to the southerly, or Ronkonkoma moraine.

The Ronkonkoma moraine of Long Island and the moraines of the Cape Cod region are largely formed of folded and deformed members of the Manhasset beds, which according to both Fuller, and Woodworth and Wigglesworth (1934) are next younger than the Gardners clay and are the equivalents of the Illinoisan, or Third Glacial. Recently MacClintock and Richards (1936) have correlated the Gardners clay with the Cape May formation of New Jersey, which is of Sangamon or third interglacial age. Thus, the Manhasset would fall in the earlier part of the Fourth Glacial, or Wisconsin. This correlation is accepted by Flint (1935) and applied specifically to Marthas Vineyard and Cape Cod. With such a correlation the ridges, known as moraines, are obviously due to shove by the same ice sheet which deposited the materials. How great an interval there may have been between the glacial deposition of the Manhasset and its deformation by ice shove there is at present no means of estimating.

The moraines of southeastern Massachusetts and their correlative, the Ronkonkoma of Long Island, under this interpretation probably represent the earliest Wisconsin substage, or Iowan. The interval of time between their formation and that of the Harbor Hill-Watch Hill moraine is long and corresponds to the Peorian. After withdrawal of the ice there was a considerable period of weathering. This interstadial is possibly not completely represented in the famous Farm Creek section of Illinois (Leighton, 1926). However, observations by Leighton and Bryan in 1938 indicate that additional information on the climate of the interstadial may be obtained by further study of this locality.

As the warmer climate of the Peorian interstadial deteriorated, a forward movement of the ice toward the position of the Harbor

Hill moraine occurred. How long a time interval is required for forward movement over the area from which the Ronkonkoma (Iowan) ice had retreated is unknown. It may easily be that the red varved clays of the New Haven-Berlin area were laid down during the recession of the Ronkonkoma ice. If so, they were weathered in the interstadial and overridden by the Harbor Hill ice. The confused varves at the top and the evidences of disturbance described by Antevs (1922 and 1928) may be due to this overriding and also to erosion and solifluction during the retreat from the Harbor Hill moraine.

In the calculation of elapsed time, Antevs, in his book of 1928, is conservative. For the St. Johnsbury substage he estimates the intervals x and y (fig. 13) as 1,400 to 2,400 years, without stating the evidence on which these figures are based. Using this estimate he has obtained for the age of the St. Johnsbury substage a total of 16,400 to 17,400 years, plus z, or the time of final melting north of Cochrane, Ontario. His figure for the moraines of Long Island is $26{,}600+x+y$, or 28,000 to 29,000 years.

However, it is possible to make a re-estimate, using a somewhat arbitrary system. If the assumption is made that the rate of retreat in the intervals unrepresented by measurements of varves, or by other chronological data, is similar to that of adjacent intervals that are so represented, a total as shown in column 4, table 3, can be computed. Here the Ronkonkoma to Harbor Hill interval is omitted as being impossible to estimate. Harbor Hill to Hartford is estimated by applying the rate of recession of the next northerly interval to the distance which is 95 km., or 1,235 years, and arbitrarily adding 800 years as the estimated time that the ice lingered on the moraine. Thus, the interval becomes 2,000 years. The intervals x and y are estimated by applying the rates of the next intervals, yielding 9,000 and 1,200 years respectively. The interval z, or 1,500 miles, is arbitrarily given a rate of retreat half that of the previous interval, and thus yields 1,000+ years. However, there remains a time interval u, from the last disappearance of the ice in Labrador to the present. The totals for St. Johnsbury and for Harbor Hill by this method are $26{,}200+u$ and $32{,}300+u$, and thus considerably higher than Antevs' totals.

In 1931 Antevs again published on this subject, recording new observations in Canada. His statements in this paper are in many instances cryptic, and it may be that he is here misinterpreted. He redivides the retreat and uses arbitrarily stated figures. Thus, the interval z, the Post-glacial, is given as 9,000 years. This figure is ex-

plained in part on his pages 18 and 19, where detailed studies of the advance and retreat of the ice near Cochrane are discussed. The retreat from Montreal River extended 50 miles north of Cochrane, and is measured by varves totaling 2,025 years. The ice then readvanced to the Cochrane moraine in a time interval estimated as 200 years. These years are excluded from the Post-glacial, which consists of the retreat from Cochrane and the final disappearance of the ice, including the remaining time to the present. The Post-glacial is preceded by the slight advance of the ice to Cochrane which is presumably correlatable with a climatic shift toward the cold, such as was coincident with the last Yoldia Sea in Europe. The 9,000 years of Antevs' estimate is thus obviously the 8,700+ of the European reckoning of the age of this last Yoldia Sea.

The retreat from Mattawa to Cochrane is estimated (column 5, table 3) at 6,000 years. This figure includes the 2,025 plus 200 years of the Montreal River-Cochrane interval previously explained, plus 3,775 years arbitrarily assigned to the interval *y*.

The interval from St. Johnsbury to Mattawa is reduced to 10,000± years as a result of recent work on Niagara Gorge by Johnston (1928) and further study by Antevs. However, a critical reading of the discussion (Antevs, 1931, pp. 20-24) does not reveal the number of years actually assigned to the interval Stony Lake-Mattawa, the time of Lake Algonquin, or any comment on the interval *x* (St. Johnsbury-Stony Lake). It appears, therefore, that this new estimate is largely arbitrary, although it may be very nearly correct and is certainly entitled to much respect by reason of Antevs' long consideration of the problem of the age of Lake Algonquin.

The estimate of the time involved in the interval St. Johnsbury to Ronkonkoma is unrevised and not discussed, so that its existence must be inferred from the statements that the total time to the "New York Moraine," or Ronkonkoma, is 36,500 years.

The foregoing estimate has been recalculated in column 7, in the same fashion as the previous estimate is revised in column 4 of table 3. Accepting Antevs' new estimate of 1,500 years for the Montreal River-Cochrane interval, and 725 years for the retreat beyond Cochrane, with 200 years as necessary for the readvance to Cochrane, the Post-glacial retreat from Cochrane at the rate for the previous interval will be 1,875 years. There is also the unknown length of time from the final disappearance of the ice to the present, or *u*. Antevs (1931, pp. 18-19) also gives a new estimate for the Mattawa-Montreal River interval as 1,000 years. Such a time interval could be arrived at by assuming any reasonable rate, and differs by only 200

years from the estimate of column 4, table 3. It may then be accepted. Also, Antevs' (1931) new estimate of 10,000 years for the two intervals St. Johnsbury-Stony Lake and Stony Lake-Mattawa, although not completely supported, is doubtless not far from correct. Furthermore, using the varves as a basis, the Hartford-St. Johnsbury interval is 4,100 years. If then the same approach is used for the retreat from the Harbor Hill moraine, the interval is 2,000 years. By this substitution the time back to the St. Johnsbury is $15{,}300+u$, and to the Harbor Hill $21{,}400+u$. If the interval u is 7,000 years, as assumed by Antevs, these intervals become 22,300 and 28,400 years.

VALIDITY OF RESULTS

The foregoing tedious survey reveals a closet of dry bones in which there survives an emaciated creature having promise for the future, but of little value in the battle of the moment. Estimates have been piled on estimates and added to known time intervals, none too securely tied to the geologic framework. If, however, the data of table 3 are examined, the elapsed time to the St. Johnsbury moraine has been estimated by somewhat different methods to give the following results: $16{,}400+z=25{,}400$; $26{,}200+u=33{,}200$; $25{,}000\pm$; and 22,300 years. All these figures are of the same order of magnitude. The Harbor Hill, or what many consider essentially the equivalent, the Ronkonkoma moraine, is estimated with the following results: $28{,}000+z=37{,}000$; 32,300; 36,500; and 28,400 years. These estimates are also of the same magnitude. It is true, of course, that all these figures are influenced by the same basic measurements and estimates and particularly by the assumption of 9,000 years for the length of Post-glacial time. This figure is obviously based on the rather well-supported European figure, but as it has a magnitude of more than a third, or, at least, a fourth of any one of the totals, it affects them all to an almost dominating extent.

Antevs' estimates of 1931 are obviously improved over those of 1928, largely because of the adjustment for the life of Lake Algonquin, based on the history of Niagara Falls. His estimate of $25{,}000\pm$ years for the St. Johnsbury moraine may eventually be reduced, as indicated in column 7, table 3. The reduction, however, will probably be moderate. Similarly, his estimate of the date, and the time elapsed since the New York (Ronkonkoma) moraine, which he assumed to be the climax of the Wisconsin, is more likely to apply to the Harbor Hill moraine. It may be that the reduction of this interval to 28,400 years may prove to be too conservative. To the extent that

the calculations of Milankovitch are accepted, any of these estimates of the age of the Harbor Hill moraine are much too low.

If now the dates of the North American chronology are compared with those of Europe, the concordance is not as close as could be desired. It is obvious that none of the existing estimates, however ingenious, or based on however much laborious work, is as yet so close to the true figure that it must be accepted without qualification. In truth, we have not yet arrived at such a stage in research on the Pleistocene. The figures given are merely first approximations which with some confidence may be considered of the correct order of magnitude. They may be received with respect, but the inherent errors are so great that the figures in years must be considered merely as indicators of relative age, rather than true figures. They are pegs on which to hang ideas.

If we consider the errors of the several dates, the amount of error varies. Thus, the length of the Post-glacial rests on the incompletely published work of Lidén, but it has been checked as to relative lengths of the intervals by archeological means as far back as the Ancylus and Litorina stages. Also, many pollen analytical studies have been made which reach back into the Gothiglacial substage. These studies confirm the order and general relative length of the substages of the younger Late-glacial and Post-glacial substages. The error in estimation of the length of the Post-glacial substage is probably small and its true length is neither longer nor shorter by more than 10 percent.

As the Fenniglacial period has been measured both in Sweden and in Finland by varve counts, which agree within 100 years, the error in the length of this period is so small that the total error in the elapsed time to the present is no greater than that involved in using the much longer Post-glacial interval.

However, the length of the Gothiglacial is not so well-determined and an estimate of 2,500 years for this time interval is subject to error of as much as 500 years, and in fact, 3,000 years is accepted by many workers. Furthermore, the length of the Daniglacial is uncontrolled by varve counts and is a pure estimate. The date given in Europe for the Pomeranian moraine depends largely on the length of time assigned to the Daniglacial. It is likely that Antevs' date for the St. Johnsbury is more nearly correct. Assuming, therefore, 25,000 years as the elapsed time since the Pomeranian, this estimate may be too large by 25 percent, or too small by as much as 30 percent.

Estimates of the elapsed time to the Brandenburg moraine have no actual basis. In America Antevs' estimate for the "New York" moraine involves a long varve count and therefore, has a value for

the minimum. If 35,000 years is adopted, the figure is 10,000 years longer than the elapsed time to the Pomeranian moraine. The date is, therefore, a minimum; the time figure may be much larger and as great as 60,000 years.

Estimates of the elapsed time to the Iowan is almost purely speculative, but there is every geologic reason for believing that Kay's estimate (1931) of 55,000 years is a minimum, and that the true figure may be twice as large.

These doubts and questions may be put in summary form by listing the time intervals with estimates of the corresponding errors, as in table 4.

TABLE 4.—*Elapsed Time to Important Ice Advances of the Wisconsin, with Estimates of the Percentage Error*

Short designation	American substages	European substages	Years from 1900	Date B. C.	Range in error of estimates:	
					(too small)	(too large)
					percent	*percent*
	Post-glacial (beginning of, at Cochrane)	Post-glacial (beginning of, at Ragunda)	8,700	6,800	10	10
W4	?	Fennoscandian moraine	10,400	8,500	10	10
		Scanian halt	13,400	11,500	15	10
W3	Mankato	Pomeranian	25,000	23,100	30	25
W2	Tazewell-Cary	Brandenburg	35,000	35,000	75	25
W1	Iowan	Warthe	65,000	65,000	100	10

GLACIAL SUBSTAGES IN COLORADO CORRELATED

In table 5 a correlation is made between the substages of the last glaciation in the Rocky Mountains and those of the continental glaciers of North America and Europe. There is in this correlation a large uncertainty. The only available method of making such a correlation is by a general argument, as it is as yet impossible to use either the vertebrate fossils or the cultural remains as guide fossils.

The line of argument is as follows: 1, the pre-Home substage is almost completely obliterated by erosion, a condition, in view of the position of the ice mass in a narrow mountain canyon, more or less comparable to the degree of weathering of the Iowan; 2, the Home moraine retains its topographic form, and the small lateral rock gorge is fresh and shows little weathering, a condition com-

parable to the degree of preservation of the Tazewell-Cary moraines, formerly considered early Wisconsin; 3, the Corral Creek moraine is fresh in form and lacks weathering, much like the Late Mankato moraines of Minnesota. The sequence appears to fit fairly well, although there is no provision for the decided oscillation of the Early Mankato, unless moraines of that age form part of the morainic complex of the Corral Creek substage. 4, The Long Draw substage, by reason of its modest moraines and other evidences of its existence, appears to be recessional, and its correlation with the Cochrane and Fennoscandian moraines seems appropriate. Such an arrangement leaves the Scanian halt without a counterpart.

TABLE 5.—*Correlation and Dating of Rocky Mountain Glacial Stages*

Short designation	North European Continental substages	North American Continental substages	Cache la Poudre Valley, Colorado	Antevs' generalized dating from 1900	Milankovitch's generalized dating from 1800
W4	Post-glacial		Protalus rampart		
	Fennoscandian	Cochrane (?)	Long Draw	10,000±	
	Scanian	?	?		
W3	Pomeranian	Late Mankato (St. Johnsbury)	Corral Creek	25,000±	19,500 to 29,500
W2	Weichsel (Brandenburg)	Tazewell-Cary (Harbor Hill)	Home	35,000±	67,000 to 78,000
W1	Warthe (Fläming moraine)	Iowan (Ronkonkoma)	Pre-Home		111,000 to 122,000

This correlation can only be defended by a negative and inconclusive argument that the Home can hardly be other than the climax of the Wisconsin, as understood in North America. If such an assignment is made, the strong readvance of the ice of the Mankato substage, separated from the Tazewell-Cary by an interstadial climate, as shown by the Two Creeks Forest bed (Wilson, 1932), seems to correspond to the similar advance of the Corral Creek moraine. The interval between the Home and Corral Creek substages seems to be too long to fit into any other place in the glacial sequence. The Corral Creek moraine may represent all of the Mankato, but the highest level of its outwash plain is doubtless the equivalent of the Late Mankato. For the present considerations, the glacial substage is traced to the plains by means of the terraces of glacial outwash,

and therefore the late stage of the moraine is the time represented by the terrace.

If this correlation is accepted, the Corral Creek moraine, the Kersey terrace, and the old floor of the Lindenmeier Valley were completed approximately 25,000 years ago. The Long Draw moraine, the Kuner terrace, and the dissection of the Lindenmeier Valley occurred approximately 10,000 years ago. The reader will have no illusions about these dates, and will realize that even if the correlations here made between the valley glaciers of Colorado and the continental ice sheets are entirely correct, the dates themselves are subject to large errors, as previously set forth.

FOLSOM CULTURE OF LATE-GLACIAL AGE

SUMMARY OF EVIDENCE

The difficulties of geochronological work have been reviewed, and the uncertainties set forth. It is now necessary to make application to the antiquity of the Folsom culture.

In brief, the culture layer of the Lindenmeier Valley shows that the Folsom hunters camped on the edge of a springy meadow, when the adjacent minor streams flowed at the level of the 20-foot terrace of these streams. This terrace, traced 30 miles down these minor streams, is correlative with the Kersey terrace of the main rivers of eastern Colorado. Here also, sites at Kersey and at Dent indicate that Folsom hunters camped and hunted on the borders of the river flood plains during this stage. Traced up the Cache la Poudre River, the Kersey terrace is the equivalent of the No. 4 terrace in the mountain canyon. In the narrow rock-walled gorges, the remnants of this terrace are small and infrequent. With reasonable assurance this terrace is interpreted as the valley train of glaciers that extended from the now empty cirques of the high mountains to Chambers Lake and to similar elevations in other canyons. This is the Corral Creek substage of glaciation.

The correlation of this hitherto unrecognized stage of glaciation in the Rocky Mountains with continental glaciation in central and eastern United States involves much uncertainty. It is however thought to be the equivalent of the Late Mankato-St. Johnsbury substage, which in turn is considered the equivalent of the Pomeranian substage in northern Europe. Such a correlation has provided a date in years. Antevs has estimated the St. Johnsbury as separated from our time by 25,000 years, and has argued that the Pomeranian has about the same antiquity. The validity of this date has been

considered in some detail. It is without much question of the right order of magnitude and can be no more than 25 percent too large, or on the other hand more than 30 percent too small.

As the camps and relics of Folsom man are found on the completed surface of the terraces, or in the upper gravel, the culture should be younger rather than older than the climax of this glacial substage. No evidences of Folsom implements have as yet been discovered on the Kuner, the next younger terrace. This terrace and its equivalent, the Long Draw glacial substage are apparently younger than the culture. On a comparable line of reasoning the Long Draw is considered to be the equivalent of the Cochrane and Fennoscandian substages, to which an age of 10,000 years may be assigned.

Thus, the Folsom culture of this area and the Lindenmeier site in particular, have an antiquity which is between 10,000 and 25,000 years, if the errors inherent in the methods used are not too great. These methods have been very thoroughly reviewed. It is obvious that much more confidence can be placed on the statement that the culture is older than 10,000 years, than on the statement that it is as old as 25,000 years. However, it is believed by the writers that the age must be much nearer 25,000 years than 10,000.

EVIDENCE FROM OTHER FOLSOM SITES

Other sites at which Folsom or Folsom-like points have been found in association with extinct animals afford some data on this antiquity. The most important is the locality in the Portales Valley of New Mexico, known as the Clovis site (Howard, 1935). Here, in "bluish" sand, silt, and clay, have been found artifacts and the bones of mammoth and bison. Weathering from these materials, Folsom and Yuma points are found. Diatoms, invertebrate shells, and charcoal from a hearth have been discovered and identified. All point to a climate cooler than the present. In an attempt to fix the date of these deposits, Antevs (1935) has made a number of assumptions: 1, that the "bluish" silts represent lake beds; 2, that these lakes are contemporary with the high stand of Lake Estancia, an ancient lake 160 miles to the west; 3, that Lake Estancia reached its highest stage of water level after the maximum of the Wisconsin glaciation. It should be noted, however, that there is no confirmatory evidence that the moist conditions in the Portales Valley coincided with the high stand of Lake Estancia. This is a plausible but unproved assumption. If it is true, the question then arises whether Antevs' assumption that the Pluvial period, coinciding with the high stand of Lake

Estancia, came after the Wisconsin maximum, or coincided with it, or with one of the later substages of glaciation. As Antevs (1935, p. 310) gives 25,000 years for the culmination of the Wisconsin glaciation, he obviously refers to the Late Mankato-Pomeranian substage, whereas others would place the culmination at the Tazewell-Cary-New York-Brandenburg substage. If the glacial history of the Southern Rocky Mountains herein outlined is followed, and the dates accepted, there were at least four Wisconsin glacial substages: the earliest, or pre-Home, of unknown date, the others 35,000+, 25,000±, and 10,000± years ago. The present writers place the climax of the Wisconsin at the time of the Home-Tazewell-Cary-New York-Brandenburg substage, some 35,000+ years ago.

Regardless of the merits of Antevs' meteorological argument that the pluvial periods in the country south of the Rocky Mountains are later than the glacial advances and not coincident with them, it is obvious that there is no direct proof that the lakes are associated with one of these glacial substages rather than with another. The obvious method is to consider the cultural and faunal materials. On such a basis, the Clovis beds may easily be of the same age as the culture layer of the Lindenmeier Valley. The presence of Yuma points, so far not found at the Lindenmeier site, gives a measure of uncertainty to such a correlation.

Folsom points associated with mammoth remains have also been found at Angus, Nebr. (Figgins, 1931), at Miami, Tex. (Sellards, 1938), and 30 miles from Abilene, Tex. (Bryan and C. N. Ray, 1938). None of these localities affords any present help in the problem of a definitive association of the Folsom culture with a datable geologic horizon. At Lake Mojave, in California (E. W. and W. H. Campbell, 1937), Folsom points have been found but not in place. Flint flakes in beach gravel show that man was present when the lake stood high, but his cultural status is uncertain. Rogers (1939, p. 43) states that not only flakes but implements of his Playa culture occur in gravel at this locality, but he casts doubt on the association of the gravel with the lake. The discrimination and tracing of the *Citellus* zone in Nebraska, as described by Schultz and by Lugn (1935, pp. 142-145) affords a promising lead whereby the younger artifact-bearing terraces may be dated. Furthermore, the terraces of the Colorado Piedmont may in the future be traced into the deposits associated with the continental ice in eastern Nebraska. The attribution of the *Citellus* zone to the Peorian, that is, to the interstadial between the pre-Home and Home glaciations, would place the cultures associated with the overlying loess and terrace deposits at a date much too early to fit

into the correlation here made. The continued detailed efforts of the Nebraska geologists promise to provide a solution for this difficult and intricate problem.

GEOGRAPHY OF THE FOLSOM CULTURE

The correlation in time between the Folsom culture and the Corral Creek glacial substage here presented, leads to several conclusions regarding the local and general climatic conditions.

That the climate of the northeastern Colorado Piedmont was cooler is attested by invertebrates found in the Lindenmeier culture layer (Eisley, 1937). It was at times almost Arctic, as shown by the solifluction phenomena still preserved in terrace gravel. Strong winds blew across flood plain surfaces not well protected by vegetation, so that dunes were piled up and pebbles polished and cut by drifting sand. Presumably, the precipitation in the mountain area may have been greater. In the plains, however, a dry, near-Arctic climate must be postulated, similar to that of the Canadian Great Plains. The cold drying winds from the mountains prevented the formation of true forests, so that presumably the plains were covered by prairie types of vegetation, with only scattered groves of trees.

In such a severe environment the sheltered Lindenmeier Valley, with grass and water in its springy meadow, must have been an ideal spot—a place beloved by the beasts. Here a hunting people would find year after year the necessities—water and game for food. It is, however, hard to believe that the larger grazing animals remained in the area in the winter. Just as the bison of recent history migrated southward to more genial winter climates, so the ancient bison probably also migrated. Doubtless, the hunters moved with the animals. If so, an explanation for the lack of remains of shelters at the Lindenmeier site is afforded, and an explanation is presented for the wide distribution of Folsom finds throughout the Great Plains region, from Saskatchewan to Texas.

BIBLIOGRAPHY

Alden, W. C.

1932. Physiography and glacial geology of eastern Montana and adjacent areas. U. S. Geol. Surv., Prof. Pap. 174.

Antevs, Ernst

1922. The recession of the last ice sheet in New England. Amer. Geogr. Soc. Res. Ser., No. 11.

1928. The last glaciation, with special reference to the ice retreat in northeastern North America. Amer. Geogr. Soc. Res. Ser., No. 17.

1931. Late-glacial correlations and ice recession in Manitoba. Geol. Surv. Canada, Mem. 168.

1935. Age of the Clovis lake clays. Proc. Acad. Nat. Sci., Philadelphia, vol. 87, pp. 304-312.

1936. Correlation of late Quaternary chronologies. Int. Geol. Congr., Rep. 16th Sess., U. S. A., vol. 1, pp. 213-216.

Atwood, W. W., Jr.

1937. Records of Pleistocene glaciers in the Medicine Bow and Park Ranges. Journ. Geol., vol. 45, pp. 113-140.

Atwood, W. W., and Mather, K. F.

1932. Physiography and Quaternary geology of the San Juan Mountains, Colorado. U. S. Geol. Surv., Prof. Pap. 166.

Aughey, Samuel

1876. U. S. geological and geographical survey of Colorado and adjacent territories (Hayden Survey). Ann. Rep. Progress for 1874, pp. 241-266.

Blackwelder, Eliot

1929. Sandblast action in relation to the glaciers of the Sierra Nevada. Journ. Geol., vol. 37, pp. 256-260.

1931. Pleistocene glaciation in the Sierra Nevada and Basin Ranges. Bull. Geol. Soc. Amer., vol. 42, pp. 865-922.

Brown, Barnum

1929. Folsom culture and its age (abstr.). Bull. Geol. Soc. Amer., vol. 40, pp. 128-129.

Bryan, Kirk

1926. Recent deposits of Chaco Canyon, New Mexico, in relation to the life of the prehistoric peoples of Pueblo Bonito (abstr.). Journ. Washington Acad. Sci., vol. 16, pp. 75-76.

1929. Folsom culture and its age (Barnum Brown abstract with discussion by Bryan). Bull. Geol. Soc. Amer., vol. 40, pp. 128-129.

1934. Geomorphic processes at high altitudes. Geogr. Rev., vol. 24, pp. 655-656.

1936. Geologic features in New England ground water supply. New England Waterworks Assoc. Journ., vol. 50, pp. 222-228; and Harvard Alumni Bull., vol. 39, pp. 676-681.

1937. Geology of the Folsom deposits in New Mexico and Colorado. Early man, a symposium, pp. 139-152. G. G. MacCurdy, ed. Lippincott Co., Philadelphia.

1938. Prehistoric quarries and implements of pre-Amerindian aspect in New Mexico. Science, n. s., vol. 87, pp. 343-346.

Bryan, Kirk, and Ray, Cyrus N.

1938. Long channelled point found in alluvium beside bones of *Elephas columbi*. Bull. Texas Arch. and Paleont. Soc., vol. 10, pp. 263-268. (Also printed as: Folsomoid point found in alluvium beside a mammoth's bones. Science, n. s., vol. 88, pp. 257-258.)

Campbell, E. W. and W. H.

1937. The archeology of Pleistocene Lake Mohave. Southwest Mus. Pap., No. 11, 118 pp.

Cook, H. J.

1927. New geological and paleontological evidence bearing on the antiquity of mankind in America. Nat. Hist., Amer. Mus. Nat. Hist., vol. 27, pp. 240-247.

DALY, R. A.
1934. The changing world of the ice age. Yale Univ. Press.
DE GEER, GERARD
1926. On the solar curve, as dating the ice age, the New York moraine, and Niagara Falls through the Swedish time-scale. Geogr. Annaler, vol. 8, pp. 253-283.
EISLEY, L. C.
1937. Index Mollusca and their bearing on certain problems of pre-history; a critique. Philadelphia Anthrop. Soc., Twenty-fifth Anniversary Studies, pp. 77-93. Univ. Pennsylvania.
FIGGINS, J. D.
1927. The antiquity of man in America. Nat. Hist., Amer. Mus. Nat. Hist., vol. 27, pp. 229-239.
1931. An additional discovery of the association of a "Folsom" artifact and fossil mammal remains. Proc. Colorado Mus. Nat. Hist., vol. 10, No. 4.
1933. A further contribution to the antiquity of man in America. Proc. Colorado Mus. Nat. Hist., vol. 12, No. 2.
FLINT, R. F.
1935. How many glacial stages are recorded in New England? Journ. Geol., vol. 43, pp. 771-777.
FULLER, M. L.
1914. The geology of Long Island, New York. U. S. Geol. Surv., Prof. Pap. 82.
GAMS, HELMUT
1938. Die bisherigen Ergebnisse der Mikrostratographie für die Gliederung der letzen Eiszeit und des Jungpaläolithikums in Mittel- und Noreuropa. Quartär, vol. 1, pp. 75-96.
HOBBS, W. H.
1931. Loess, pebble bands, and boulders from glacial outwash of the Greenland continental glacier. Journ. Geol., vol. 39, pp. 381-385.
HOWARD, E. B.
1935. Evidence of early man in North America. Mus. Journ., Univ. Pennsylvania, vol. 24, Nos. 2-3, pp. 61-158.
JOHNSON, W. D.
1901. The High Plains and their utilization. U. S. Geol. Surv., 21st Ann. Rep., pt. 4, pp. 599-741.
JOHNSTON, W. A.
1928. The age of the Upper Great Gorge of Niagara River. Roy. Soc. Canada, Proc. and Trans., 3d ser., vol. 22, sec. 4, pp. 13-29.
KAY, G. F.
1931. Classification and duration of the Pleistocene period. Bull. Geol. Soc. Amer., vol. 42, pp. 425-466.
LEIGHTON, M. M.
1926. A notable type Pleistocene section; the Farm Creek exposure near Peoria, Illinois. Journ. Geol., vol. 34, pp. 167-174.
1931. The Peorian loess and the classification of the glacial drift sheets of the Mississippi Valley. Journ. Geol., vol. 39, pp. 45-53.
LEVERETT, FRANK
1939. The place of the Iowan drift. Journ. Geol., vol. 47, pp. 398-407.

Lidén, Ragnar
1913. Geokronologiska studier öfver det finiglaciala skedet i Angermanland. Afhandl. Sveriges Geol. Undersökn., ser. C., No. 9.

Lugn, A. L.
1935. The Pleistocene geology of Nebraska. Nebraska Geol. Surv., 2d ser., Bull. 10.
1938. The Nebraska State Geological Survey and the "Valentine Problem." Amer. Journ. Sci., vol. 36, pp. 220-227.

MacClintock, Paul, and Richards, H. G.
1936. Correlation of late Pleistocene marine and glacial deposits of New Jersey and New York. Bull. Geol. Soc. Amer., vol. 47, pp. 289-338.

Martin, R. J.
1930. Climatic summaries of the United States. Section 23, northeastern Colorado. U. S. Weather Bur.

Milankovitch, M.
1930. Mathematische Klimalehre und astronomische Theorie der Klimaschwankungen. Handb. Klimatol., 1, A, Berlin.

Ray, Cyrus N.
1938. The Clear Fork culture complex. Bull. Texas Arch. and Paleont. Soc., vol. 10, pp. 193-207.

Ray, Louis L.
1935. Some minor features of valley glaciers and valley glaciation. Journ. Geol., vol. 43, pp. 297-322.
1938. Recent physiographic development along the northern Front Range (abstr.). Proc. Geol. Soc. Amer. 1937, p. 314.

Richter, Konrad
1937. Die Eiszeit in Norddeutschland. Gebrüder Borntraeger, Berlin.

Roberts, F. H. H., Jr.
1935. A Folsom complex, preliminary report on investigations at the Lindenmeier site in northern Colorado. Smithsonian Misc. Coll., vol. 94, No. 4.
1936. Additional information on the Folsom complex, report on the second season's investigations at the Lindenmeier site in northern Colorado. Smithsonian Misc. Coll., vol. 95, No. 10.
1937. The Folsom problem in American archeology. Early man, a symposium, pp. 153-162. G. G. MacCurdy, ed. Lippincott Co., Philadelphia.

Rogers, Malcolm J.
1939. Early lithic industries of the lower basin of the Colorado River and adjacent areas. San Diego Mus. Pap., No. 3, 75 pp.

Romer, A. S.
1929. A fresh skull of an extinct American camel. Journ. Geol., vol. 37, pp. 261-267.
1933. Pleistocene vertebrates and their bearing on the problem of human antiquity in North America. American Aborigines, publ. for pres. at 5th Pacific Sci. Congr., Canada, pp. 47-85. Univ. Toronto Press.

Sauramo, Matti
1928. The Quaternary geology of Finland. Bull. Comm. Geol. Finlande, No. 86, pp. 1-110.

Schultz, C. B.
1932. Association of artifacts and extinct mammals in Nebraska. Nebraska State Mus., Bull. 33, vol. 1, pp. 271-282.
Sellards, E. H.
1938. Artifacts associated with fossil elephant. Bull. Geol. Soc. Amer., vol. 49, pp. 999-1010.
Soergel, Wolfgang
1925. Die Gliederung und absolute Zeitrechnung des Eiszeitalters. Fortschr. Geol. und Pal., vol. 13, 251 pp.
1937. Die Vereisungskurve. Gebrüder Borntraeger, Berlin.
Taylor, F. B.
1913. Niagara Falls and Gorge. 12th Int. Geol. Congr., Canada, Guide Book No. 4, pp. 5-70.
Van Tuyl, F. M., and Lovering, T. S.
1935. Physiographic development of the Front Range. Bull. Geol. Soc. Amer., vol. 46, pp. 1291-1350.
Wahlstrom, E. E.
1939. Geology of west central Boulder Co., Colorado. Unpublished doctorate thesis, Harvard Univ.
Wentworth, C. K.
1936. An analysis of the shapes of glacial cobbles. Journ. Sed. Petrol., vol. 6, pp. 85-96.
Wilson, L. R.
1932. The Two Creeks Forest bed, Manitowoc Co., Wisconsin. Trans. Wisconsin Acad. Sci., vol. 27, pp. 31-46.
Woodworth, J. B., and Wigglesworth, Edward
1934. Geography and geology of the region including Cape Cod, the Elizabeth Islands, Nantucket, Marthas Vineyard, No Mans Land, and Block Island. Mem. Mus. Comp. Zoöl. Harvard Coll., vol. 52.
Zeuner, F. E.
1935. The Pleistocene chronology of central Europe. Geol. Mag., vol. 72, pp. 350-376.

1. Spring at the Lindenmeier site. The water seeps out along the top of the tuff-clay several feet above the top of the storage tank. The tents of the Smithsonian Institution Expedition are on the level of the old valley floor.

2. Brennigan Spring. The light-colored ground is covered with the ordinary grama grass of the dry hills and plains. The dark areas extending down the sides of the gulch are meadow grasses supported by the emerging ground water.

1. The Kersey terrace. View to the north, across the terrace to the South Platte River. Folsom artifacts have been found in the dune sand in the foreground, which rests on the Kersey terrace.

2. View to the east from the summit of Prairie Divide. Plains of the Colorado Piedmont in background. Valley in foreground filled with irregular masses of slumped gravel and glacial debris.

The Home moraine, as seen from the upstream side. The Cache la Poudre River flows from right to left in front of the moraine, and through the channel between the moraine and the left valley wall.

1. View across the valley of the Cache la Poudre River at Home Post Office. Home moraine shows as grassy slope in lower left. Glacial erratics of pre-Home glacial substage shown at A and B.

2. The Corral Creek moraine as seen from upstream side. Note subdued aspect and lack of boulders on the surface of this relatively young moraine. Corral Creek flows through a notch in moraine on right.

1. Pitted outwash plain of the Long Draw substage. Corral Creek cirque in the background (see near view below).

2. Protalus rampart of the Corral Creek cirque. Small patches of snow have remained throughout the summer in sheltered niches in the headwall of this cirque (September 1936).

Facsimile Reprint, 2007

GUSTAVS LIBRARY
www.gustavslibrary.com

Republished in association with
ANCIENT SOCIETY BOOKS